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ENVIRONMENTAL ASPECTS of the TRANSURANICS

A Selected, Annotated Bibliography

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NEVADA APPLIED ECOLOGY GROUP Nevada Operations Office

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ENVIRONMENTAL ASPECTS OF THE TRANSURANICS A SELECTED, ANNOTATED BIBLIOGRAPHY

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Nevada Applied Ecology Information Center
Ecological Sciences Information Center
Information Center Complex
Information Division

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ABSTRACT

This seventh published bibliography of 500 references is compiled from the Data Base on the Environmental Aspects of the Transuranics built to provide information support to the Nevada Applied Ecology Group (NAEG) of ERDA's Nevada Operations Office. The general scope is environmental aspects of uranium and the transuranic elements, with emphasis on plutonium. Laboratory and field studies dealing with the effects of plutonium 239 on animals are highlighted in this bibliography. Supporting information on ecology of the Nevada Test Site and reviews on the effects of other radionuclides upon man and his environment has been included at the request of the NAEG. The references are arranged by subject category with first authors appearing alphabetically in each category. Indexes are given for author, geographic location, keywords, taxons, permuted title and publication description.

PREFACE

This publication of 500 references is the seventh in a series of bibliographies published by the Nevada Applied Ecology Information Center to provide information support to the Nevada Applied Ecology Group (NAEG) of ERDA's Nevada Operations Office. The scope is centered on the environmental aspects of plutonium, but has been expanded to include uranium and the transuranics. Studies on the ecology of the Nevada Test Site, redistribution and resuspension, low-level radiation effects, and reviews and bibliographies on other radionuclides have been included at the request of the NAEG. The subject category, Biological Aspects, is subdivided to separately list the plant and animal studies. A majority of the references deal with several subject areas requiring multiple categories; however, each entry is chosen to be categorized according to the main subject area described. Laboratory and field studies dealing with the biological effects of plutonium 239 on animals are emphasized in this bibliography. Current and pre-1962 domestic literature as well as foreign literature is actively sought. This bibliography contains literature dating back to May, 1944.

Indexing for the Data Base on the Environmental Aspects of the Transuranics conforms with the definitions of concentration ratio, inventory ratio and transfer coefficient by the Plant Uptake Panel at the ERDA/DBER Workshop on Environmental Research for the Transuranium Elements held in Seattle, Washington, November 11-14, 1975. These definitions are as follows:

- Concentration Ratio = CR
  (unitless)

$$CR = \frac{\text{Activity/Unit Dry Wt. Product Material}}{\text{Activity/Unit Dry Wt. Reference Material}}$$

Examples:

Uptake; $CR_{(\text{Plant/Soil})} = \frac{\text{dpm/g Dry Plant}}{\text{dpm/g Dry Soil}}$

Translocation; $CR_{(\text{Seed/Leaf})} = \frac{\text{pCi/g Dry Seed}}{\text{pCi/g Dry Leaf}}$

- Inventory Ratio = IR
  (unitless)

$$IR = \frac{\text{Activity/Unit Area in Product Material}}{\text{Activity/Unit Area in Reference Material}}$$

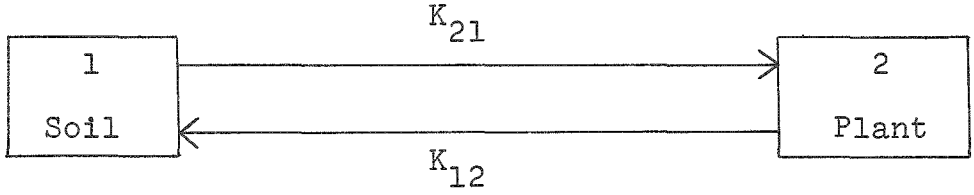
Examples:

$$IR_{(Plant/Soil)} = \frac{(\text{Plant Concentration})(\text{Plant Biomass})}{(\text{Soil Concentration})(\text{Soil Depth})(\text{Bulk Density})}$$

$$= \frac{(pCi/g\ Dry\ Plant)(g\ Dry\ Plant/m^2)}{(pCi/g\ Dry\ Soil)(m\ Soil)(g\ Dry\ Soil/m^3)}$$

- Transfer Coefficient = K = Fraction/Unit Time

Example:



All the published literature references are contained in the Data Base on the Environmental Aspects of the Transuranics and are available for searching upon submission of specific requests.

Citation Form

The references are arranged by subject category with first authors appearing alphabetically within each category.

As a result of computer limitations in indicating superscripts and subscripts in the standard manner, certain conventions have been established in the bibliography:

1.) X sub t (X being a variable) means X_t or X subscript t.

2.) In chemical compounds and elements, NaIO3 (for example) means $NaIO_3$.

3.) 10(E+3) or X(E-3) (E denoting exponent) means 10^3 or X^{-3}, respectively.

4.) For units of measurement, such as centimeters, meters, feet, etc., X3 means X^3.

Indexes

Indexes are provided for: 1.) authors, 2.) geographic location, 3.) keywords, 4.) taxons, 5.) permuted title and 6.) publication description.

ACKNOWLEDGEMENTS

P. B. Dunaway, Director of the Bioenvironmental Sciences Division, Nevada Operations Office and M. G. White, Scientific Director of the Nevada Applied Ecology Group, Nevada Operations Office, have closely guided the Nevada Applied Ecology Information Center in selection of material for this project.

Appreciation is due to the many researchers who have contributed their publications for inclusion in this bibliography. R. G. Shreckhise, Pacific-Northwest Laboratories, assisted in the explanations of the indexing terms. G. R. Eisele of the Comparative Animal Research Laboratory, Oak Ridge, has collaborated with the information center in collecting and indexing documents on the biomedical aspects of plutonium in man and animals.

Ruth Slusher of the Computer Sciences Division, ORNL, and Faye Fletcher and staff of the Information Storage and Retrieval Processing Section of the Information Center Complex, ORNL, have managed the computer production of this document.

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Report Number	Title
ORNL-EIS-72-21 (NVO-AEIC-72-21)	"Environmental Aspects of Plutonium--A Selected, Annotated Bibliography", Environmental Plutonium Data Base Group (September, 1972)
ORNL-EIS-73-21 (Suppl. 1) (NVO-AEIC-73-21)	"Environmental Aspects of Plutonium and Other Elements --A Selected, Annotated Bibliography", Environmental Plutonium Data Base Group (August, 1973)
ORNL-EIS-74-21 (Suppl. 2) (NVO-AEIC-74-21)	"Environmental Aspects of Plutonium and Other Elements --A Selected, Annotated Bibliography", Environmental Plutonium Data Base Group (February, 1974)
ORNL-EIS-74-21 (Suppl. 3) (NVO-AEIC-74-21A)	"Environmental Aspects of the Transuranics--A Selected, Annotated Bibliography", F. M. Martin, C. T. Sanders and S. S. Talmage (December, 1974)
ORNL-EIS-75-21-No. 5 (NVO-AEIC-75-1)	"Environmental Aspects of the Transuranics--A Selected, Annotated Bibliography", R. A. Faust, F. M. Martin, C. T. Sanders and S. S. Talmage (June, 1975)
ORNL-EIS-75-21-No. 6 (NVO-AEIC-75-2)	"Environmental Aspects of the Transuranics--A Selected, Annotated Bibliography", F. M. Martin, R. A. Faust and C. T. Sanders (July, 1975)

SAMPLE REFERENCE

This is an example of the format for the descriptive fields used in this bibliography:

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5 - *Publication Date*
6 - *Document Title*
7 - *Publication Description*
8 - *Abstract*
9 - *Abstractor's Initials*
10 - *Comments (Pertinent Numerical Data)*

1 BIOLOGICAL ASPECTS, ANIMALS

2 <000>

3 Dagle, G.D., R.D. 4 Phemister, J.L. Lebel, R. Jaenke, and R.L. Watters, 4 Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA; U. S. Atomic Energy Commission, Division of Biomedical and Environmental Research, Washington, DC. 5 1975

6 7 Plutonium-Induced Popliteal Lymphadenitis in Beagles. Radiation Research, 61, 239-250; BNWL-SA-5119; 14 p.

8 Fifteen adult male beagles were subcutaneously implanted with 10.6 to 39.4 uCi of high-fired Pu 239 PuO2 with a mass median diameter of about 0.7 um into the left hind paws. The Pu particles accumulated in the popliteal lymph nodes. Histopathologic changes in these lymph nodes were characterized primarily by reticular cell hyperplasia, increased numbers of macrophages, necrosis, and fibroplasia. Eventually the Pu particles became sequestered by scar tissue that often replaced the normal architecture of the lymph node. Light-microscopic autoradiographs of the popliteal lymph nodes showed a time-related increase in number of alpha tracks per Pu source. Electron microscopy showed that Pu particles were aggregated in phagolysosomes of macrophages. 9 (RAF)

10 Four electron micrographs of Pu particles in popliteal lymph nodes are given.

BIOLOGICAL ASPECTS
ANIMALS

<1>
Abrams, R., University of Chicago, Chicago, IL. 1945, May

Inhalation of Plutonium. CN-2992; Part of Monthly Health Report on Problems Relating to Product for Month of May, 1945, (p. 12-15), 45 p.

An update of data from a previous study of inhalation of Pu is presented for the Arc aerosol studies and trace intubation studies. Analyses are still incomplete on the group of rats exposed to a tracer aerosol consisting of a mixture of Pu(+4) and 65 day Zn. Wide scatter points made conclusions difficult. The rate of elimination was about the same, with Zn leaving the lung somewhat faster. Half-time in the lung was about 8 days for Zn and 17.5 days for Pu. Tissue analyses have been completed for intubation experiments and will be reported in detail in a forthcoming progress report. Lung absorption with Pu(+4) nitrate or complex occurred very rapidly during the first days then subsided to a rate characteristic of Pu(+4). With Pu(+4) nitrate, absorption was slow and incomplete. Major sites of deposition were the liver and skeleton. Addition of citrate caused rapid absorption from the lungs. Calgon acts much like citrate but seemed to be a poorer complexing agent. (EBM)

<2>
Anderson, E.C., G.A. Drake, T.M. Holland, J.E. London, J.L. Perrings, and J.S. Wilson, Los Alamos Scientific Laboratory, Los Alamos, NM. 1973, March

The Hot Particle Project. Exposure of Animals. LA-5227-PR; Part of Richmond, C.R. and Woelz, G.L. (Comps.), Biological and Medical Research Group (H-4) Annual Report, January through December, 1972, (p. 1-7), 144 p.

Some of the experimental conditions for an on-going pilot study dealing with possible carcinogenesis resulting from localized irradiation of tissue by highly radioactive, insoluble microparticles with emphasis of PuO2 in the lung are given. Included is a tabular review of the Pu content of 10 batches of ZrO2 microspheres and 8 exposure levels listed in the previous year's annual report. The experiments were planned as an exploratory survey covering a wide dynamic range using 60 golden hamsters per group which were to be extended to 150 animals per group. Due to an unexpected low biological response the range of experiments was extended with a more modest number of animals. One additional group of animals was injected with 6000 spheres (0.22 pCi/sphere). The total lung burden of these animals was 1.3 nCi. In order to give exposures to much larger numbers of smaller and more mobile particles, additional groups of 30 animals were injected with total lung burdens of about 100 nCi. One group received from 1,000,000 to 2,000,000 spheres/animal (0.07 pCi/sphere), and the other received 2,000,000 spheres/animal (0.42 pCi/sphere). These two groups will be compared with the observation that 0.1 uCi lung burden resulted in a survival time of only 1 yr in rats. Twenty-four animals received Co 57 labeled spheres by intratracheal insufflation to study possible differences in foreign-body response to particles on opposite sides of the alveolar-capillary wall. A small number of rats was injected with 6000 spheres/animal (4.3 pCi/sphere) to determine if this species which has more natural lung disease showed a higher incidence of radiation damage possibily as a result of synergistic effects. (NAP)

<3>
Arnold, J.S., and W.S.S. Jee, Argonne National Laboratory, Lemont, IL; University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1957, July-September

American Journal of Anatomy, 101, 367-417.

Young female (160 gm) rats were given 5 uCi/kg of plutonium(+4) citrate intravenously and serially sacrificed between 2 hours and 147 days. Gross and detailed radioautograms of undecalcified sections of the lumbar vertebrae and femurs were done. The results show that plutonium was localized in high concentration at endosteal surfaces and to a lesser degree at periosteal and endosteal surfaces of vascular channels. No apparent selective deposition was observed with respect to the presence of osteoclastic or osteoblastic activity. New bone which was deposited after injection overlayed the strata of initially deposited plutonium. All post-injection bone was readily identified by its diffuse labeling. Where resorption occurred, plutonium derived from the resorbed bone progressively concentrated in the osteoclasts. The plutonium of the osteoclasts was later transferred to macrophages. The above circumstances uniquely demonstrated both the formative and destructive phases of reconstruction. Plutonium concentration in osteoclasts was interpreted as evidence of the active role of the cell in resorption. It is speculated that the osteoblast acts as its surface to fragment the bone and then digests the ingested bone particles in its cytoplasm, where it concentrates the liberated plutonium. The localization of plutonium in bone and the reticuloendothelial system, together with its lack of diffusibility, suggests that it is a colloid. The irreversible nature of its deposition suggests collodial adsorption as being the principal mechanism of bone fixation. (Auth)

<4>
Arnold, J.S., and W.S.S. Jee, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1959

Autoradiography in the Localization and Radiation Dosage of Radium 226 and Plutonium 239 in the Bones of Dogs. Laboratory Investigation, 8, 194-204.

Young adult beagles (14-20 months of age) were given sufficient radium chloride in Pu citrate intravenously to produce the following given levels of retained body burden: (1) .0143, (2) .086, (3) 0.27, (4) .81 and (5) 2.5 uCi/kg of body weight. Three separate autoradiographic approaches were undertaken to evaluate the gross and microscopic distribution of the elements and the distribution of radiation dosage, namely, gross distribution microdistribution and quantitative autoradiography. For the gross distribution, the over-all pattern of Pu and Ra in contact autoradiography of whole femora is surprisingly similar. Both Ra and Pu concentrate in the trabecular bone of the metaphyses of long bones and in flat bones but they are deposited in very much lower concentration in the trabecular bone epiphyses. A difference between Ra and Pu is

<4>

BIOLOGICAL ASPECTS
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<4> CONT.
seen in cortical bone, whereas a small quanity of Pa is seen diffusely throughout the cortex, Pu is virtually absent in this area. Pu shows an intense endosteal concentration lining the medullary cavities of the shaft and to a lesser extent, at the periosteal surface. For microdistribution, Pu is initially deposited in a relatively uniform layer on all calcified osseous surfaces which have a blood supply or are in contact with the liniit of the narrow spaces. If resorption occurs at such a surface, the deposited Pu concentrates in the cytoplasm of the osteoclasts. The contrast between the absence of activity in all bone that existed prior to injection and the diffuse labeling of all bone deposited after injection makes it possible to follow the sequence of bone modeling. The radiation effects on remodeling are noted. Marked differences are apparent in the concentration and distribution of the activity from one dose level to another. In the animals with the highest burden of Pu, both the resorptive and formative phases of remodeling of trabecular bone are arrested. The dose rate to soft tissue at 10 microns from the radioactive bone surface was calculated to be 45 rads/day for Pa and 100 rads/day for Pu. The actual concentration of Pa activity in bone is greater than that of Pu by a factor of 2.5. However, because of the differences in their geometric relations to the surface cells of bone, Pu proves to deliver a greater radiation dose to surface cells. (PHM)

<5>
Atherton, D.F., T.F. Dougherty, F.W. Bruenger, G.N. Taylor, and R.J. Stover, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1965, March 31

Pilot Study of the Effect of Cortisol on Trisodium Calcium DTPA Enhanced Excretion of Plutonium 239 in the Beagle. COO-119-232; Part of Dougherty, T.F., Research in RAdiobiology, Annual Report of Progress in the Internal Irradiation Program, (p. 188-198), 222 p.

A dog 688 days old was injected with 2.72 uCi Pu 239/kg. Urine and feces were later collected and analyzed for Pu 239 to determine the pretreatment excretion rates. Two massive doses of cortisol were given to mobilize Pu 239 to make it available for chelation by Na3Ca DTPA and subsequent excretion. No practically significant increase in excretion was observed, and there was no significant removal of Pu 239 from the dog's liver. (Auth) (PHM)

<6>
Atherton, D.F., B.J. Stover, W.S.S. Jee, W. Stevens, and F.W. Bruenger, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

Skeletal Retention and Distribution of Polymeric and Monomeric Plutonium 239 in Beagles. Radiation Research, 51, 538.

Pu 239(+4) was given intravenously to beagles in: (1) the Pu-transferrin complex (Pu-Tf), (2) 0.08 M citrate buffer (Pu-M), and (3) citrate buffer, pH equivalent to 6, as a suspension of near colloid size particles (Pu-P). As expected, the overall distribution of the polymeric form of plutonium does not resemble that observed when it is administered as the monomeric complex with citrate or transferrin. The skeletal retention of plutonium, when injected in a monomeric form, is 50% of the injected dose. The retention of Pu-P in the skeleton was less than 1/20 that seen in Pu-M or Pu-Tf at comparable times. The uniformity of skeletal distribution of Pu-P from bone to bone is markedly less than that seen with the two monomeric forms. Reduced skeletal retention in animals injected with Pu-P may indicate a different skeletal retention mechanism in animals injected with polymeric plutonium. Autoradiographs will be shown to clarify this point. (Auth) (Complete Article)

<7>
Bair, W.J., Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA. 1974

Carcinogenicity of Inhaled Radionuclides. CONF-740702; BNWL-SA-5049; Part of Proceedings of the Health Physics Annual Symposium held in Houston, Texas, July 7-11, 1974, (10 p.).

The carcinogenicity of inhaled alpha and beta-gamma emitting radionuclides has been demonstrated in a number of animal species. However the data from these studies are inadequate to assess with confidence the relationship between the incidence of lung cancer and the radiation dose. These data are reviewed, and possibilities for estimating the dose-effect relationships are discussed. Several tables summarizing the data are presented, one showing Pu-induced lung cancer in experimental animals from Pu citrate, nitrate, oxide and ammonium plutonium penta carbonate, and plutonyl triacetate. A graph showing the relationship between the quantity of Pu 239 PuO2 deposited and the survival time in dogs is shown as well as one of the calculated cumulative mean alpha dose to the lung from different Pu compounds administered to several experimental animals. Some of the problems associated with determining the appropriate dose value that relates to cancer incidence are enumerated. These include estimating alveolar deposition and pulmonary clearance, the unknown significance of spatial and temporal distribution of the radiation dose from the radionuclide that is deposited, and determining the tumor appearance time. Some approaches taken to estimate dose-effect relationship are mentioned such as the logarithmic probit curve and mathematical models. Because of the inadequacy of the available data, alternatives are needed to extrapolate the results from animal experiments to man for purposes of developing radiation protection standards. A possibility suggested is a toxicological approach in which the appropriate radiation dose models needed to describe cancer induction are of secondary importance. (PHM)

<8>
Bair, W.J., and J.F. Park, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1967, July

Comparative Disposition of Four Types of Plutonium Dioxides Inhaled by Dogs. BNWL-480; Part of Thompson, R.C. and Swezea, E.G. (Eds.), Annual Report for 1966, (p. 63-65), 207 p.

Groups of three dogs inhaled dry aerosols of one of four different plutonium dioxides. Two oxides were prepared by calcining the oxalate at 1000 C or at 350 C; another was produced by the ignition of the stabilized metal at 450 degrees, and another by the slow oxidation of the pure metal at 123 degrees.

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<8> CONT.
The particle size characteristics of the four aerosols were similar with count median diameters of about 0.5 u. The lung retention half-time of oxalate calcined at 350 C was about one year, half of that of the other oxides tested. The greater lung clearance of this oxide was accompanied by greater accumulation of plutonium in the lymph nodes. Translocation of plutonium to tissues outside of the lung and lymph nodes was least for the dogs which inhaled oxalate at 1000 C. Urinary excretion of plutonium as well as translocation appeared to be greatest for the oxalate calcined at 350 C. (RAF)

<9>
Bair, W.J., and D.H. Welland, Hanford Atomic Products Operation, Richland, WA. 1961, March

Plutonium Inhalation Studies. 4. Mortality in Dogs after Inhalation of Plutonium 239 PuO2. HW-68803; 24 p.

In 28 beagle dogs depositing 1 to 130 uCi of plutonium dioxide of particle size 0.50-0.65 u by inhalation, deaths due to respiratory insufficiency occurred two months to a year after exposure. Lungs contained 95 per cent and the bronchial lymph nodes 4 per cent of the total plutonium content. Clinical symptoms included increased respiratory rates, 20 per cent weight loss and marked lymphopenia. Histopathologic effects were confined to lungs and bronchial lymph nodes. It was concluded that initial deposition of 0.1 uCi Pu 239 per gram of lung would rarely cause death of a dog within a year. (Auth)

See also Radiation Research, 16, 811-821 (1962).

<10>
Bair, W.J., D.A. Willard, S. Marlos, and P.I. Hackett, General Electric Company, Hanford Laboratories, Biology Operation, Richland, WA. 1960

Preliminary Observations on the Pharmacodynamics and Biological Effects of Inhaled Plutonium Oxide in Dogs. Radiation Research, 12, 419.

Immediately after an inhalation exposure of dogs to a plutonium oxide aerosol 60% of the deposited plutonium was in the lung and the remainder was distributed between the upper respiratory passages and the gastrointestinal tract. Within two weeks after exposure, about 50% of the deposited plutonium was excreted in the feces and less than one % in the urine. The half-time for excretion of inhaled plutonium oxide was found to be as great as 1500 days in 40 week studies. Only small quantities of plutonium (less than one % of the deposited dose) were translocated from the lung to other tissues with the exception of the tracheobronchial lymph nodes. The concentration of plutonium in the tracheobronchial lymph nodes was about 30 times higher than in lung two and one-half years after pulmonary deposition of plutonium oxide. The data suggest continuous transport of plutonium from lung to lymph node with a maximum burden of plutonium accumulating in the nodes within a year after exposure. The histopathology of tracheobronchial lymph nodes and lung was described. No magligmart neoplasms have been observed in dogs following inhalation of plutonium oxide. Dogs depositing between 50 and 100 uCi of plutonium died within two to four months with massive gross lung changes. Blood lymphocyte counts showed an early decrease following the inhalation exposure. (Auth)(Complete Article)

<11>
Bair, W.J., and D.H. Willard, Hanford Atomic Products Operation, Hanford Laboratories Operation, Biology Laboratory, Richland, WA. 1962

Plutonium Inhalation Studies. 4. Mortality in Dogs after Inhalation of Plutonium 239 PuO2. Radiation Research, 16, 811-821.

Beagle dogs were exposed to Pu 239 PuO2 aerosols, at a concentration of 10(E-3) uCi of Pu 239 02 per ml of air. The median particle diameter ranged from 0.50-0.65 u. A range in the quantity of Pu deposited (1 K 130 uCi) in the dogs was obtained by varying the duration of the exposure time. Two dogs were alive 21 months after exposure. All deaths occurred 2 to 14 months after exposure and were due to respiratory insufficiency. Lungs contained 95% and the bronchial lymph nodes 4% of the total plutonium content. Clinical symptoms included increased respiratory rates, 20% weight loss, and marked lymphopenia. Histopathologic effects were confined to lungs and bronchial lymph nodes. It was concluded that initial deposition of 0.1 uCi of Pu 239 per gram of lung would rarely cause death of a dog within a year. (Auth)

See also HW-68803, 24 p. (1961).

<12>
Bair, W.J., D.H. Willard, and B.J. McClanahan, Hanford Atomic Products Operation, Richland, WA. 1960, January 15

Excretion and Translocation of Plutonium 239 Dioxide After Inhalation. HW-65500; Part of Kornberg, H.A., Hanford Biology Research Annual Report for 1959, (p. 116-121), 208 p.

More than 7% of Pu deposited in dogs by inhalation of Pu 239 PuO2 was found in lungs immediately after exposure. The half-time for whole-body retention of Pu was about 1,800 days during the period from about 10 to 40 weeks after exposures. Translocation of Pu from lung to tracheobronchial lymph nodes was a major pulmonary clearance process. Large variations in daily excretion of Pu in urine and feces were demonstrated. (Auth)

<13>
Ballou, J.E., General Electric Company, Hanford Laboratories, Biology Laboratory, Richland, WA. 1962, January-March

Removal of Deposited Plutonium by Triethylenetetranine Hexaacetic Acid. Nature, 193(4822), 1301-1304.

The effectiveness of triethylenetetramine hexaacetric acid, (TTHA), was compared with DTPA in removing deposited Pu. Adult female Sprague-Dawley rats averaging about 220 g were injected intravenously with approximately 1.3 uCi Pu as the citrate complex. DTPA was administered at pH 8-9, either orally or intraperitoneally. Pu content was determined in excreta, liver, femur and total residual carcass. The results show that prompt intraperitoneal administration of TTHA resulted in greater removal of Pu from bone than was accomplished with equivalent DTPA treatment. DTPA was however, more effective in reducing liver deposition. DTPA and TTHA were equally effective in promoting Pu excretion when given intraperiotoneally 18 days after the

<13>

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<13> CONT.
radionuclide injection. The effectiveness of the chelating agents was markedly decreased with delayed treatment. The oral administration of 6 mm/kg DTPA or TTHA reduced bone deposition to about the same extent as a 4-fold lower intraperitoneal dose. The TTHA treatment was somewhat more effective than DTPA particularly with regard to the removal of Pu from the liver. At the lower oral dosage level of 2.8 mm/kg the superiority of TTHA over DTPA was more toxic than DTPA and resulted in severe diarrhea and death of one animal. At a higher dosage of 7.5 mm/kg severe diarrhea was observed with both chelating agents and 50% mortality occurred in the TTHA animals by the 4th day. TTHA is the first substance to show promise of a practical degree of oral effectiveness in removing Pu. (FMM)

Table 1 shows comparative effectiveness of DTPA and TTHA in removal of Pu.

<14>
Ballou, J.E., Hanford Atomic Products Operation, Richland, WA. 1962, January 15

Metabolism of Neptunium. HW-72500; Part of Kornberg, H.A. and Swezea, E.G. (Eds.), Hanford Biology Research Annual Report for 1961, (p. 41-43), 180 p.

Dust samples were obtained from Union Carbide and Nuclear Company, Paducah, Kentucky, for evaluation as a potential health hazard. Radiochemical analyses of the Paducah dust indicated gross alpha contamination of 0.26 uCi/g; 60 per cent due to Np 237 and the remainder from uranium isotopes. The dust was administered either acutely or chronically to rats to determine gut absorption and toxicity. Twenty-four hour retention of a single gavage feeding amounted to about 1 per cent of the administered dose. The dust was fed as a water suspension containing 0.054 uCi Np 237 and 14 mg of associated mixed solids. The buildup of Np 237 in rats fed a diet containing 1.4 per cent Paducah dust for a 31-day period is shown. Food consumption and weight gain appeared normal on this diet which provided an average dose of 0.042 uCi Np 237/day. The body burden of Np 237 attained after 31 days feedings was 2.5 per cent of the daily dose or less than 0.1 per cent of the total amount ingested. Intestinal absorption of neptunium citrate solutions ranked according to valence state was Np(+6) > Np(+5) > Np(+4). Absorption of the most stable form, Np(+5), was about 1 per cent of the administered dose. (Auth) (FMM)

<15>
Ballou, J.E., and J.L. Palotay, Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA

Oral Therapy for Deposited Plutonium. Health Physics, 12, 895-899.

Young adult female rats weighing 250 g were administered chelating agents (DTPA and related compounds) by gavage 1 hr after plutonium citrate injection and at daily intervals thereafter. DTPA and TTHA (triethylenetetraminehexacetic acid) were given as the monocalcium-sodium salts at pH 6-7. DTPA pentaethyl esters were adjusted to pH 4. Effective oral therapy for plutonium in rats was obtained with a TTHA dose of 3 m-moles/kg administered 1 hr after plutonium citrate injection. Daily oral administration of a 1.5 m-moles/kg dose, initiated 1 hr after plutonium injection and continued for 9 days, was only marginally effective. Measurement of the enhanced excretion of plutonium in the bile during perfusion at different intestinal segments with chelating agents indicated that the agents are absorbed on oral therapy are discussed. (RAF)

<16>
Barron, E.S.G., University of Chicago, Chicago, IL. 1945, May

Phospholipid Turnover in Product Poisoned Animals. CN-2992; Part of Monthly Health Report on Problems Relating to Product for Month of May, 1945, (p. 5-11), 45 p. (Declassified January 4, 1956)

An experiment was devised to check the validity of the observations that Pu treated rats developed a fatty appearing liver. Metabolism of phospholipids in the rats gave an indication of deranged fat metabolism resulting in the gross pathological picture observed. Control female rats were fasted for 40 hours then injected into the stomach with 0.5 cc/200 gm of 0.62 mg P/cc inorganic phosphate followed by 1 cc. of cod liver oil. In Pu animals, 2 mg/kilo of Pu was given intravenously 5 days before P 32 administration. Blood was taken from the Pu animals for white count, non-protein nitrogen and cholesterol estimations. Animals from both groups were sacrificed at 3, 6, 9, 15, 30, 60, and 102 hours after initial feeding of the phosphate. The entire gastrointestinal tract and feces collected were ashed to determine the extent of P absorption, and the liver was analyzed. The animals in the Pu series showed more individual variations than in the control series, but this did not exceed 10-15%. The intestinal absorption of P 32 was not impaired by the amount of Pu higher than in the controls. This could be explained by the initial parts of the curves (0-9 hrs) were similar showing transport of P to the liver and renewal of P in phospholipid molecules was not affected by Pu poisoning. The peak of the curve is postponed to 15 hrs in Pu animals as compared to 9 hrs in the controls. This is difficult to explain as the livers did not appear fatty. The white count was low, nonprotein nitrogen (NPN) and cholesterol seemed normal. (BRM)

<17>
Baxter, D.W., M.W. Rosenthal, and A. Lindenbaum, Argonne National Laboratory, Division of Biological and Medical Research, Argonne, IL. 1973, July

Plutonium Decorporation by Glucan and Related Compounds as Adjuncts to DTPA Therapy. CONF-730431; Part of Proceedings of the 21st Annual Symposium of the Radiation Research Society held in St. Louis, Missouri, April 29-May 3, 1973. Published in Radiation Research, 55(3), 516.

DTPA, currently the treatment of choice for plutonium poisoning, is limited to removal of extracellular plutonium because it is essentially unable to penetrate cell membranes. The effectiveness of yeast glucan, given as an adjunct to DTPA therapy has been demonstrated in removing additional hepatic plutonium previously unavailable for chelation by DTPA. To elucidate the mechanism of glucan action, other substances have been tested. These include isosclerotan, bacterial cell wall

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<17> CONT.
polysaccharides, a pyran copolymer, poly I/C, Tilarone, and Triton WR 1339. Each compound was administered, in conjunction with DTPA, to mice injected intravenously with mid-range polymeric plutonium five days previously. Four of the tested substances removed significant additional plutonium from the liver by 6 weeks. Of these, the most effective (pyran copolymer) and least effective (Tilarone) are soluble interferon-inducers. Additional studies with pyran have shown that 1) another pyran copolymer is also effective in removal of hepatic plutonium, 2) removal is effected in about one week, and 3) hepatic plutonium removed by pyran is not translocated to bone in the absence of DTPA as is that removed by glucan. The two compounds with intermediate effectiveness were glucan and isosclerotan. These are insoluble, morphologically different but chemically similar, glucopolysaccharide constituents of yeast and fungal cell walls, respectively. (Auth) (Complete Article)

<18>
Belyaev, Yu.A., 1964

Relative Efficiency of Certain Complex Compounds in the Removal of Plutonium 239 from the Organism. AEC-tr-6408; Part of Radiobiology, (p. 125-128); Radiobiologiya, 4(5), 760-763.

Plutonium in the form of the citrate was injected intraperitoneally into rats in doses of 0.8-1.0 uc/rat. The following chelating agents were administered parenterally at different times after Pu administration: 1) Ca Na3 salt of triethylenetetraaminehexaacetic acid (TTHA), 2) Ca Na salt of tetraethylerepentaaminehaptaacetic acid (TPHA), 3) Ca Na salt of 2,2'-diaminodiethylsulfide of tetraacetic acid (TS), and 4) Ca Na5 salt of diethylenetriaminepentamethyl- phosphinic acid (DTPPA). The strongest effect at early stages was shown by TTHA. This complexone was several times more efficient than DTPA which was taken as the standard for the efficiency of the other complexones. The effect of TPHA was somewhat weaker than that of TTHA but still stronger than DPTA. The least effective was TS, which is therefore of no interest for further research. DTPPA was effective for the removal of plutonium from soft tissues and skeleton although on the whole its efficiency was less than that of TTHA, TPHA and DTPA. When treatment complexones was started 30 days after the injection of plutonium, the efficiency of TTHA did not differ from that of TPHA and DTPA. (RAF)

Tables are given of Pu content in rat organs (liver, kidneys, spleen, skeleton) 3, 16 and 45 days after administration of complexons.

<19>
Belyaev, Yu.A., Not given. 1964

Plutonium Removal in Rats Given Some Complexons by Mouth. AEC-tr-7590; Part of Moskalev, Yu.I. (Ed.), Distribution, Biological Effects, and Accelerated Excretion of Radioactive Isotopes, (p. 356-360), 405 p.

Experiments were conducted on male rats, weighing 220-270 grams, given a solution of plutonium nitrate intraperitoneally, pH 6.5, at a concentration of 0.66 to 1.01 uCi/rat. The complexons were given by mouth using a gastric catheter at different times following the Pu injection. Organs analyzed for Pu content were kidneys, spleen, liver and skeleton. It was found that EDTA and DCTA, (1,2-diaminehexanetetraacetic acid) by mouth was ineffective, even at the early stages, with respect to Pu removal from the skeleton or liver. EDPA was effective only when given 2 or 6 hours after the Pu injection. Multiple administration of EEDTA 1 day after administration of Pu lowered the Pu level in both the liver (1.6-fold decrease) and skeleton (65% of the control); however, when it was given 30 days after Pu, the effect was chiefly due to the Pu level in the liver (2-fold decrease). The best response was obtained with DTPA which diminished Pu content of the liver and skeleton regardless of time of administration. When this agent was given 30 days after Pu, there was a 4.5-fold decrease in its level in the liver and a 1.6-fold decline in the skeleton (61% of the control). (RAF)

Tabular data give Pu 239 levels in rat skeleton and liver 3 days after ingestion of complexon, in rat organs on the 16th day, and on the 83th day with late administration of complexions.

<20>
Belyaev, Yu.A., and V.K. Lemberg, Not given. 1964

Effectiveness of Diethylenetriaminepentaacetic Acid Following Intratracheal Administration of Plutonium. AEC-tr-7590; Part of Moskalev, Yu.I. (Ed.), Distribution, Biological Effects, and Accelerated Excretion of Radioactive Isotopes, (p. 361-366), 405 p.

Experiments were conducted on 86 Wistar rats weighing 160-180 g; Pu was administered intratracheally as the nitrate, pH 2, and the ammoniumpentacarbonate, pH 7.4. The Pu solutions were given in a volume of 0.3 ml containing 0.74-0.9 uCi Pu/rat. Ca DTPA was given both intratracheally and intraperitoneally. The Pu content of liver, whole lungs and femur was analyzed. The effectiveness of DTPA, with reference to removal of Pu 239 given in the form of the nitrate or carbonate complex intratracheally from the lungs, was negligible, even at the early stages of treatment. Intratracheal administration was somewhat more effective than intrapertioneal. Pu-pentacarbonate of ammonium, when given intravenously was 80% retained in the liver. The mean excretion of Pu 239 in urine was 0.1% and in feces 12% (between the 1st and 7th days). Single intraperitoneal administration of DTPA (24 hours after intravenous administration of a Pu-carbonate complex) lowered the Pu 239 content of the liver by 23%. (RAF)

<21>
Berdjis, C.C. (Ed.), Armed Forces Institute of Pathology, Washington, DC. 1971

Pathology of Irradiation. Williams and Wilkins Company, Baltimore, Maryland, 710 p.

The book presents the current knowledge of the effects of radiation on man and animals and reviews the latest literature available on the subject. Attempts have been made to correlate the structural and often the ultrastructural features of tissue reaction to irradiation with the clinical biophysiological, genetic and functional aspects as they are manifested during and after irradiation. The problems of extrapolating animal data to man are

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discussed. Two chapters, one dealing with bone-seeking radionuclides, such as Pu 239, Ra 226, Ra 228, Th 228 and Sr 90, and the other with toxicity aspects of internally deposited Pu 239 have been abstracted separately for the data base. Other chapters include the effects of irradiation in mammalian cells in vitro, clinical uses of radioisotopes, radiation carcinogenesis, the effects of radiation on skin, the nervous sytem, salivary glands, gastrointestinal tract, liver, cardiovascular system, endocrine glands, hematopoietic system, lymphatic system, thymus, pulmonary system, genitourinary tract, kidneys and organs of special senses. The effects of acute irradiation in man are described as well as treatment for the restoration of the hematpoietic system, such as by transfusions of compatible autologous or isogenic bone marrow. (FMM)

<22>
Bernard, S.R., and C.F. Holoway, Oak Ridge National Laboratory, Oak Ridge, TN. 1965, October

Estimate for Fluorine 1 for Plutonium Compounds. ORNL-3849; Part of Health Physics Division Annual Progress Report for Period Ending July 31, 1965, (p. 212-213), 257 p.

Experimental data on rats are reviewed which permit some fluorine 1 estimates to be made of some Pu compounds. Particular reference is made to studies by Weeks, et al, and Ballou. For the present it is suggested that fluorine 1 equals 2 x 10(E-2) for ingestion of monomeric Pu and 2 X 10(E-5) for ingestion of Pu as an aged colloid. No data are available for the estimation of managed colloidal solutions of Pu(+4). (RAF)

<23>
Bland, M.R., J.F. Loutit, and J.M. Sansom, Medical Research Council, Radiobiology Unit, Harwell, England. 1974

Histochemical Phosphatases and Metachromasia in Murine Tumors Induced by Bone Seeking Radionuclides. British Journal of Cancer, 29, 206-221.

Tumors induced in mice, either CBA normal and chimaerical, or C3H, by Sr 90 or Ra 226 or plutonium have been examined histochemically with (1) diazotate fast red violet LB salt in naphthol AS-MX phosphate buffer at pH 8.6 and 5.2, (2) 1·9 dimethyl methylene blue (Taylor). It is concluded that the diagnosis of osteosarcoma is facilitated with Taylor's Blue which stains osteoid metachromatically. Cells of osteosarcoma, like normal osteoblasts, contain alkaline phosphatase but this may be lost by mutation either in the original tumor or subsequently on passage of the tumor serially to compatible hosts. Osteosarcomata may contain giant-cells of two forms, bizarre tumor cells and osteoclasts; the latter contain acid phosphatase. Osteosarcomata which retain their osteoid on serial passage have few cells containing acid phosphatases. Primitive mesenchymal cell tumors of angiomatous form may occur, if the bone marrow is irradiated, e.g. by Sr 90-Y 90 and Pu. These tumors lack osteoid and cells interpretable as osteoblasts or osteoclasts (though they destroy bone). Tumours classifiable as fibrosarcomata occur rarely, and may be truly of fibroblastic origin or be mutated osteosarcomata. Lymphomata also occur when the marrow is irradiated Sr 90-Y 90 and Pu). They may be generalized, when their cells may contain alkaline phosphatase or lack it. They may be localized to abdominal viscera, the reticulo-sarcomatous form, in which case the cells lack alkaline phosphatase. (Auth)

<24>
Bleaney, B., Churchill Hospital, Medical Research Council, Bone-Seeking Isotopes Research Unit, Oxford, England. 1967

Radiation Dose-Rates Near Bone Surfaces in Rabbits after an Injection of Plutonium. Physics in Medicine and Biology, 13(1), 145-160.

Rabbits 6 weeks old given single intravencus injections of 1.25 uc/kg of plutonium nitrate were killed at different times after injection. Undecalcified sections of femurs and vertebrae were prepared, and the dose rates determined by track counting on autoradiographs. In trabecular bone, 24 hours after injection, the ratio of maximum to minimum dose rates to stem cells outside the endosteal surface is about 3:1. All the trabecular bone surfaces have a deposit of Pu 239. At 16 weeks after injection, about one fifth of the trabecular bone surface still has a significant dose rate, and only a few per cent of the surface has no plutonium deposit, even though nearly all the trabecular bone has been formed since injection. Since most of the endosteal bone surface is trabecular bone, a large volume of stem cells and marrow cells is irradiated by these deposits. There is also a significant dose rate due to plutonium in the marrow. (Auth) (RAF)

Tabular date are given on dose rates in trabecular bone in femurs and vertebrae. The distribution of dose rates is shown in graphic form.

<25>
Boecker, B.B., R.G. Cuddihy, F.F. Hahn, and R.O. McClellan, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

A Seven-Year Study of the Pulmonary Retention and Clearance of Cesium 137 Inhaled in Fused Aluminosilicate Particles by the Beagle Dog. LF-49; Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974 (p. 48-52), 384 p.

Long-term pulmonary retention and clearance were studied using 30 beagle dogs given single, 15-min inhalation exposures to Cs 137 labeled fused aluminosilicate particles (AMAD=1.5 to 1.7 um, sigma sub g=1.6 to 1.8). An average of about 60% of the initial body burden was excreted rapidly primarily in the feces; the remainder was retained for much longer periods. In 2 dogs observed for 7 years after exposure, the longest component of whole-body retention had an associated biological half-life of 580 days. Tissue analyses for dogs sacrificed in pairs out to 7 years after exposure showed prolonged retention in the lung, transfer of significant quantities to the tracheobronchial lymph nodes and some soft tissue accumulation of released Cs 137. Results have been incorporated into a kinetic model to study the relative importance of various lung clearance mechanisms. These data on long-term lung retention and translocation to tracheobronchial lymph nodes

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<25> CONT.
were significantly different than those observed previously in dogs exposed by inhalation to Pu 239 Pu O2. (Auth)

<26>
Boyatov, L.V., and Z.T. Kalmykova, 1961

Investigation of the Functional State of the Blood System in Dogs in the Long-Term Periods after Chronic Influence of Ionizing Radiation. AEC-tr-5265; Part of Lebedinskii, A.V. and Moskalev, Yu.I. (Eds.), Biological Effects of Radiation and Problems of Radioactive Isotope Distribution, Translated from a publication of the State Publishing House of Literature in the Field of Atomic Science and Technology, Moscow, USSR, (p. 32-42), 187 p.

Twenty-three dogs from 17-33 kg in weight were divided into four groups for different treatments. The 1st group received chronic gamma irradiation in doses of 10 R/day up to a total of 1300 R. For the 2nd group, Pu nitrate was introduced in the blood in amounts of 0.05 uCi/kg four times with an interval of one month. The combined effects of gamma irradiation and Pu were investigated in the 3rd group and the 4th groups received chronic external gamma irradiation in amounts of 18 R/day up to a total dose of 945 R. There was also a control group. Certain stresses were applied to the animals, such as massive or repeated bloodlettings and the intramuscular introduction of defatted milk and adrenalin. The results show that in all dogs, both experimental and controls, the reaction of the peripheral blood to the introduction of milk was monotypic and consisted of the development of pronounced neutrophilic leucocytosis. Certain differences in the course of restoration of the blood after massive blood loss were present in the experimental dogs, in comparison with the controls. In dogs with a long period after chronic irradiation (group 4), regeneration of the peripheral blood occurred more rapidly than in the controls. In all the animals with repeated bloodlettings, the amounts of erythrocytes and hemoglobin decreased after repeated blood losses. During the period of bloodletting, the numbers of reticulocytes increased five to seven times. Normobolization of the erythrocyte content in all dogs occurred 21 days after cessation of the bloodletting, with the exception of the animals in group 2 in which it was delayed until the 32nd day. In the irradiated animals, a sharper and more prolonged deceleration of the blood clotting was observed after the first blood loss than in the controls. Although in the controls the clotting time increased from seven-eight to 10 min, in the irradiated animals it increased to 16 min. Normalization of the clotting occurred after a day in the controls, and after several days in the experimental dogs. The changes revealed in some of the experimental dogs indicate that complete restoration of the functional activity of the hemopoietic system and the organism as a whole does not occur in all cases and depends largely on the periods after chronic irradiation influence. (PMM)

<27>
Borisov, V.P., Not given. 1964

Changes in Correlation Between Isotopes in a Mixture of Products of Uranium Fission with Resorption Thereof from the Digestive Tract. AEC-tr-7590; Part of Moskalev, Yu.I. (Ed.), Distribution, Biological Effects, and Accelerated Excretion of Radioactive Isotopes (p. 99-102), 405 p.

An aged solution of fission fragments (2 years old) containing 91% rare earth elements (Ce 144, Sr 90, Yttrium 90 and Zr 95) was administered through a thin catheter into the rat's stomach in large doses (75 uCi/kg) to provide adequate concentration in internal organs and tissues after resorption. The rats were sacrificed on the 3rd day, tissues and organs were measured radiometrically. Strontium, Yttrium, and, in part, zirconium, were 90-96% concentrated in bone tissue. More than 50% of the Ce 144 accumulated in the skin. The percentile of strontium in the liver was lower than in the initial solution. The distribution of isotopes in bones, muscles, liver and skin were 96.70, 0.75, 0.04 and 2.51%, respectively, for strontium; 96.6, 0.91, 0.05, 2.44% for yttrium; 23.5, 15.02, 2.38 and 59.1% for cerium; and 90.7, 1.5, 0.24, 7.56% for zirconium. (RAF)

Tabular data are given on the characteristics of solutions used for radiochemical analysis, radiochemical composition of initial solutions and biomedia, cumulative activity in organs, comparative radiometric and radiochemical data and distribution of isotopes in organs.

<28>
Borisov, V.P., and R.S. Krivchenkova, Not given. 1964

Acceleration of Excretion of Radioactive Isotopes, Evaluation of Some Immediate Measures Against Injury by Radioactive Substances. AEC-tr-7590; Part of Moskalev, Yu.I. (Ed.), Distribution, Biological Effects, and Accelerated Excretion of Radioactive Isotopes, (p. 303-311), 405 p.

Several agents were tested as emergency care following intake of U 238, Po 210, Ce 144 and Sr 90 in the digestive tract. Albino rats weighing 200-250 g were administered radioisotopes intraperitoneally or intragastrically in doses of 10-15 uCi/kg. Drugs were given immediately after intake of the radioisotope; the rats were sacrificed after 3-5 days. Polonium, Ce and Sr tissue and organ levels were estimated radiometrically, U by fluorescence. Simultaneous intake of U and sodium bicarbonate in the gastrointestinal tract, of U and heavy metal antidote, cerium and complexons increased deposition of radionuclides in tissues and organs. Activated charcoal did not prevent absorption of the radionuclides tested. A decrease of effectiveness of Na3 Ca DTPA was noted when Ce 144 penetrated into the digestive tract as compared to its effectiveness when Ce 144 was given intraperitoneally. There are contraindications against the use of complexons for gastric lavage or recontamination of the mouth, since experiments proved that with penetration of complexons in the stomach, in cases of oral Ce 144 poisoning, there was a sharp increase in level of deposition of the radioisotope in the liver and bones. A beneficial response (decreased deposition in the kidneys) was obtained in experiments involving administration of U 238 to animals with the use of phosphates. It was demonstrated that antidotum metallorum and "dry hydrogen sulfide" (hydroquinone sulfhydrate) were effective against polonium in the stomach, barium sulfate was effective against strontium 90 poisoning, and fluorexon--against Ce 144 lesions. Fluorexon (N, N-di-carboxymethyl

<28>

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<28> CONT.
aminomethylfluroescein) diminished deposition of Ce 144 in the skeleton and liver, concurrently. (RAF)

<29>
Boyd, H.A., C.G. Raabe, and P.K. Peterson, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

Production of Monodisperse Respirable Aerosols of Americium 241 Dioxide and Evaluation of In Vitro Dissolution. LF-49; Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 1-7), 384 p.

A method is described for the production of monodisperse (sigma sub g less than 1.2) particles of Am 241 AmO2 for use in inhalation experiments with dogs and rodents. The effects of physical and chemical factors on the production of polydisperse aerosols of Am 241 AmO2 were studied and evaluated. The best aerosol was achieved when a suspension of americium hydroxide with 2.5 mg Am/ml at pH=7.3 was aerosolized and passed through two heating columns in succession, the first at 300 degrees C and the second at 1050 degrees C. The particles were roughly spherical and had densities near 8 gm/cm3 the aerosol AMAD and sigma sub g were about 1.5 um and 1.7, respectively. Monodisperse particles were separated and collected with the Lovelace Aerosol Particle Separator (LAPS) and subsequently suspended in deionized water with pH adjusted to 10.2 with NH3 for nebulization to produce mondisperse aerosols for inhalation exposures. Particles collected on filters during inhalation experiments were used for evaluation of in vitro dissolution rates with two systems and various forms of a lung fluid simulant. The important role of phosphate ions in such dissolution systems was demonstrated, suggesting the potential for the equally important role of free phosphate in retarding dissolution of AmO2 particles in the lung. (Auth)

<30>
Brooks, A.L., R.J. LaBauve, R.O. McClellan, and D.A. Jensen, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

Chromosome Aberration Frequency in Blood Lymphocytes of Animals with Plutonium 239 Lung Burdens. LF-49; Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 165-169), 384 p.

Other investigators have suggested a causal relationship between accident Pu 239 exposures in man and the presence of chromosome aberrations in blood lymphocytes. To assess this relationship experimentally, 16 Rhesus monkeys and 171 Chinese hamsters were exposed by inhalation to Pu 239 PuO2 aerosols and an additional 5 hamsters were injected with Pu 239 citrate and the frequency of aberrations in blood lymphocytes determined. Lung burdens in the hamsters were estimated by serial sacrifice and radiochemical analysis. After an initial rapid clearance phase, the Pu 239 was retained in the monkey lung with a long effective half-life > 500 days. At 30 days after inhalation, 99% of the sacrifice body burden was in the lungs of both species. The ranges of cumulative radiation dose to the hamster lungs 30 days after inhalation were calculated to be 80-170, 220-540 and 830-2120 rads for initial lung burden levels of 10-30, 30-70 and 180-260 nCi/g, respectively. By 120 days, these doses were calculated to be 40-350, 500-710 and 1440-2170 rads. Hamsters with the highest lung burdens had a median survival time of about 80 days. No deaths occurred in any of the other treated hamsters or monkeys by 250 days after Pu 239 inhalation. Hamsters sacrificed at 30 days showed an increase in chromosome aberration frequency with increasing dose to lung of 0, 0, 0.014 and 0.089 aberrations/cell in the controls, 80-120, 220-540 and 830-2120 rad groups, respectively. By 120 days after inhalation, the aberration frequency in the controls was 0.012. The frequency in animals with doses that produced significant life shortening (1440-2170 rads) had decreased to 0.018 and 0.032 aberrations/cell in animals with lung doses of 500-710 rads. At 380 days after injection of 60 nCi Pu 239 citrate/gm, hamster lymphocytes had an aberration frequency of 0.048 aberrations/cell. The level of chromosome damage in the Pu 239 PuO2 exposed monkeys at 30 and 90 days after inhalation was not different than observed in controls. (Auth)

<31>
Brooks, A.L., R.F. Peters, and J.C. Retherford, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

The Effect of Microdose Distribution on Chromosome Aberrations Frequency in Liver Cells of the Chinese Hamster Following Exposure to Plutonium 239 PuO2 or PLutonium 238 PuO2 Particles. LF-49; Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974 (p. 174-178), 384 p.

Chinese hamsters were injected intravenously with Pu 239 Pu O2 or Pu 238 Pu O2 particles of known size or with Pu 238 citrate to determine the effect of particle size and specific activity on the frequency and distribution of chromosome damage in the liver. Three particle sizes were used in the Pu 239 PuO2 experiment. 0.15, 0.44 and 0.89 um, and all animals were injected with a constant activity, 5 x 10(E-4) uCi Pu 239/gm body weight. The Pu 238 PuO2 was injected in three particle sizes, 0.17, 0.41 and 1.1 um and at three activity levels. The Pu 238 citrate was injected at 5 x 10(E-3) uCi Pu 238/gm body weight. Hamsters injected with Pu 239 PuO2 were sacrificed at 15, 42 and 122 days after injection and those injected with either Pu 238 PuO2 or Pu 238 citrate were sacrificed 12 days after injection. The approximate sizes and distribution of particles were determined by autoradiographic methods. The number of alpha tracks/star increased as a function of the particle size injected. A change in particle size with time was noted as smaller particles were aggregated into larger ones by the phagocytic action of Kupffer cells. Injection of Pu 239 PuO2 and Pu 238 PuO2 produced a distribution of chromosome damage which was non-poisson in nature. Plutonium 239 PuO2 produced increased damage with increasing average dose with some cells containing a large number of aberrations, but there was relatively little particle size effect. Conversely, aberration frequencies after Pu 238 PuO2 injection were

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inversely related to particle size and no cells were seen with large amounts of damage. The Pu 238 citrate produced 6 x 10(E-3) aberrations/cell/rad which was a higher rate than observed for Pu 238 particles. This rate is similar to that observed previously for Pu 239 citrate. Risk for the production of cellular damage in the liver was greater per uCi following injection of either Pu 238 or Pu 239 citrate than it was following deposition of the same amount of Pu 239 PuO2 or Pu 238 PuO2 particles. (Auth)

<32>
Bruenger, F.W., D.R. Atherton, and B.J. Stover, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1963, March 31

Studies of the Oxidation States of Plutonium 239 in Injection Solutions. COO-225; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 62-72), 136 p.

A study was made to determine what spontaneous changes occur in the Pu 239 injection solutions during the interval (1-3 days) between preparation of the solution and injection of the dog. By a combination of precipitation and spectrophotometric methods it has been shown that the plutonium injected into the dogs is about 98% Pu(+4) and 2% Pu(+6). (Auth) (PMM)

<33>
Bruenger, F.W., W. Stevens, D.R. Atherton, G.N. Taylor, and B.J. Stover, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

The Effect of the Physical-Chemical State of Plutonium on Its Early Distribution in the Liver. Radiation Research, 51, 539.

The early deposition and subcellular distribution of Pu(+4) 239 in canine liver following administration of either strictly monomeric Pu(+4) as a transferrin complex (Pu-Tf), non-polymeric Pu(+4) in citrate buffer pH 3.5(Pu-M), or largely polymeric Pu(+4) in citrate buffer pH 6 (Pu-P) has been studied. Large differences in the quantities deposited and the intraorgan distribution pattern in the liver were observed. Liver depositions ranged from 25% of total dose for the strictly monomeric (Pu-Tf), an average of 32% for Pu-M, to equivalent to 70% for the largely polymeric material. Autoradiographs show that initially Pu-M is deposited uniformly and diffusely in hepatic cells whereas Pu-P was found largely in random clusters in reticuloendothelial cells. Cellular distribution patterns of Pu-Tf and Pu-M injected dogs were quite similar. Liver homogenates of a Pu-M injected dog and the animal injected with Pu-P also were studied by differential and isopycnic sucrose density gradient procedures. Monomeric plutonium was initially associated with soluble liver proteins, i.e., ferritin, and was found at later times with subcellular particles rich in mitochondria and also with lysosomes. In these organelles, most of the nuclide was either membrane bound or possibly associated with heavy granular material. In homogenates of liver obtained from dogs injected with Pu-P most of the nuclide sedimented with nuclei or mitochondria. No association of Pu-P with soluble proteins could be demonstrated even at very short times after injection. (Auth) (Complete Article)

<34>
Bruenger, F.W., W. Stevens, B.J. Stover, and D.L. Berliner, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1964, September 30

Chemical State of Plutonium(+4). COO-119-231; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 99-109), 173 p.

The method of gel-filtration was used to study in vitro the binding and the distribution of Pu(+4) in dog plasma. It was found that the main portion of Pu was bound by albumin. Only a small amount of plutonium was associated with high molecular weight proteins. The medium weight globulins of type 75 and 4-55 were essentially free of plutonium. (Auth)

<35>
Bruenger, F.W., B.J. Stover, W. Stevens, and D.R. Atherton, University of Utah, College of Medicine Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1968, March 31

Note on the Exchange of Plutonium 239 Between Tranferrin and Ferritin in Vitro. COO-119-237, Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 153-157), 168 p.

The transfer of Pu 239(+4) from transferrin, which is the transport protein for iron, to ferritin, which is a storage protein for iron, has been investigated by gel filtration and gel electrophoresis. Using blood serum from a beagle and equine ferritin. The results show that the reaction Pu(+4)-transferrin + ferritin-transferrin + Pu(+4)-ferritin occurs in vitro at pH 8, and that under the specific conditions of this experiment the ferritin complex is more stable than the transferrin complex. (Auth)

<36>
Bruenger, F.W., B.J. Stover, and W. Stevens, University of Utah, College of Medicine, Salt Lake City, UT. 1969, March 1

On the Binding of Americium 241 in the Canine Liver. COO-119-240, Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work ir Progress in the Internal Irradiation Program, (p. 139-161), 279 p.

When Am 241(+3) in citrate burfer was injected intravenously, about half was deposited in the liver of the beagle. The liver was separated into five fractions which are connective tissue, nuclei and debris, mitochondria and lysosomes, microsomes, and soluble material. The concentration of Am 241 was significant in all five fractions. The soluble fraction was separated according to molecular weight, and Am 241 was found with the material of highest weight, of approximately 450,000 M.W., and of approximately 1500 M.W. The material of highest weight with which Am 241 was associated was tentatively identified as lipofuscin. The material of 450,000 M.W. was purified and identified as ferritin. The association of Am 241 with ferritin is of high stability. The material of approximately 1500 M.W., with which only a small amount of the Am 241 was associated, was not identified. Analysis of a digest of

<36>

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<36> CONT.
the microsomal fraction showed Am 241 bound to ferritin and to an unidentified material of high weight. The reaction Am(+3)-transferrin + ferritin results in transferrin + Am(+3)-ferritin was shown to occur in vitro as is the case with Pu(+4). Limited results show the Pu 239 may also be strongly bound by ferritin in the liver of the living dog.

<37>
Brues, A.M., H. Auerbach, G.M. DeRoche, and D.D. Grube, Argonne National Laboratory, Argonne, IL. 1966, December

Mechanisms of Carcinogenis. ANL-7278, Part of Biological and Medical Research Division Annual Report, 1966, (p. 132-134), 324 p.

This progress report deals with the study and definition of conditions under which tumors are induced by local irradiation, with special emphasis on the skin and immediately underlying tissues. Findings suggest that mouse mortality depends strongly on the portion of body irradiated. After irradiating a somewhat smaller portion of the body surface (50-60%) than in a previous study with 7200 rads external beta radiation, mice survived wellofr 6 months. No tumors appeared after 7200 or 5000 rads (16 and 11 hours exposure). A sharp fall in leucocytes and lymphocytes was observed in the first week, followed by a rapid recovery to normal values. Studies on skin sections of hairless mice treated with 5000 rads surface dose which were given tritiated thymidine before sacrifice showed that DNA synthesis was markedly reduced for one or two days after irradiation and then rose to values which exceed the control. Studies on the carcinogenic activity in rats are continued with implants of Silastic, solid and porous Teflon, cellophane, porous fiberglass prefilters, solid discs of reactor grade graphite, and millipore filters of 6 graded pore sizes. Our attempt is made to relate the growth rates of benign and malignant mammary tumors in rats to the histologic characteristics of these tumors, to the age of the animals and to their exposure to x-rays or to alpha radiation from injected particulate Pu 239. Mylar implants containing 5, 10 or 15 uCi Sr 90-Y 90 placed subcutaneously in female rats were observed for one year and compared to animals with Mylar implants without radioactivity. Animals with radioactive sources showed sarcomas arising from the capsule and additional subcutaneous fibrosarcomas. Findings fo experiments in which particulate Pu was injected subcutaneously or intramuscularly into rats were as follows: rats retained, at about 1 1/2-2 yrs. following injection, 25-45% of the dose at the subcutaneous site of injection; the skeleton retained 8-16% of the dose; about 1-2% was found in the liver and 0.2-0.3% in spleen. A comparison of mice injected subcutaneously with particulate Pu 239 (1.33 ug) and ionic Pu 239 (1.20 ug) showed that with the former, 48% remained at the injection site and 11% appeared in the skeleton; with the latter, 3% remained at the site and 26% was deposited in bone. (RAF)

<38>
Brues, A.M., H. Auerbach, G.M. DeRoche, and D.D. Grube, Argonne National Laboratory, Argonne, IL. 1965, December

Mechanisms of Carcinogenesis. ANL-7136, Part of Biological and Medical Research Division Annual Report, 1965, (p. 164-166), 338 p.

Sprague-Dawley female rats each received 8 simultaneous subcutaneous injections totalling 9.9, 2.2, or 1.3 ug of polymeric, particulate Pu 239. Also, because of the known high incidence of mammary tumors in intact females and of an apparent increased incidence in plutonium-injected rats, the two higher dose levels were administered to castrated females. An additional group received a single injection of 1.3 ug intramuscularly into the right thigh muscles. In mice, a single subcutaneous injection of 1.3 ug of polymeric, particulate Pu 239 was given and its effect was compared with that on a group receiving 1.3 ug ionic (soluble) Pu 239. Local and skeletal burdens were measured as a function of time, and tumors were examined histologically. Two years after subcutaneous injection of particulate Pu 239, about 35% of the injected amount remained in the area of injection. Total skeletal burdens in excess of 1 ug appeared after the high-level injections, and bone tumors appeared in these rats after 360 days. Where the total injections were below 2.6 ug, skeletal burdens were less than 0.2 ug and no bone tumors appeared. The castrate group showed somewhat higher skeletal burdens than the corresponding intact animals. Six months after intramuscular injection there was a retention of about 80% in the injected muscle. Injection-site sarcomas in rats began to appear in the high-dose groups at 360 days, the same time as the beginning of appearance of bone tumors. In mice injected with particulate Pu 239 the first bone tumor appeared at 328 days; in those injected with ionic material at the same dose (and with higher skeletal burdens) the first tumor appeared at 225 days. No tumors at the site of injection appeared in mice. When particulate plutonium was injected subcutaneously, autoradiographs showed "stars" in the area of local injection indicating highly polymeric material. Single tracks were seen in the skeleton, liver, spleen, and in locally induced sarcomas indicating that transfer from the site of primary deposition occurred following depolymerization or solubilization. (FMM)

<39>
Brues, A.M., H. Auerbach, G.M. DeRoche, and L.M. Pilarski, Argonne National Laboratory, Argonne, IL. 1964, December

Mechanisms of Carcinogenesis. ANL-6971; Part of Biological and Medical Research Division Annual Report, 1964, (p. 47-48), 223 p.

The carcinogenicity of locally injected Pu 239 was examined comparatively in species of different size. Local injections of particulate suspensions of plutonium were given to rats and mice and a series of female rats was ovariectomized before injection in order to prevent the ordinarily high incidence of mammary tumors. Larger animals (rabbits and dogs) will be included in later experiments. Since particulate plutonium is removed from the injection site (as inhaled plutonium particles are from the lung) mainly through incorporation into macrophages, experiments were carried out using suspensions of plutonium 239 particles to determine their effects on macrophages in tissue culture. The fate or cells which ingest these alpha-emitting particles will be studied by lapsed-time cinematography. From the results, it appears that particulate plutonium is a satisfactory preparation for

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<39> CONT.
inducing subcutaneous tumors since local tumors were beginning to occur in rats given injections of 1.0 and 0.4 uCi. (FMM)

<40>
Bukhtoyarova, Z.M., V.K. Lemberg, and F.S. Freisinger (Translator), Academy of Medical Sciences, USSR. 1959

Tumors Develcping in Rats after Intraperitoneal Injection of Plutonium Nitrate (Plutonium 239). Voprosy Onkologii, 5(8), 140-148; Problems of Oncology, 5(8), 13-24.

White rats weighing 110-130 g were administered plutonium nitrate as a single intraperitoneal injection at pH 2 in doses of 6.3 x 10(E-3), 4.0 x 10(E-3), 1.89 x 10(E-3), 0.63 x 10(E-3) and 0.315 x 10(E-3) uCi/g. Survival time, peripheral blood changes and pataological changes in organs and tissues were studied. The average survival time with Pu doses of 6.3 x 10(E-3), 4.0 x 10(E-3) and 1.89 x 10(E-3) uCi/kg was considerably shorter than that of the controls. Findings suggest that development of osteogenic sarcomas represent the most important late consequences of accumulation of Pu 239 in the body. All five doses caused appearance of osteogenic sarcomas and of various soft tissue tumors (mammary gland, endocrine gland, pituitary tumors) in the rat. The dose of 1.89 x 10(E-3) uCi/kg of Pu nitrate represented the optimal sarcomogenic dose. Osteogenic sarcomas were characterized by multicentric growth and by polymorphous structure. Soft tissue tumors showed a greater variety and were less differentiated than in the control animals. (RAF)

Doses and number of animals bearing tumors, and localization and type of soft tissue tumors are given in 2 tables. The relation between the development of osteosarcoma and dose and time is given in graphic form.

<41>
Buldakov, L.A., R.A. Frokhin, and A.P. Nifatov, Ministry of Health, Institute of Biophysics, Moscow, USSR. 1968

Kinetics of the Plutonium 239 Metabolism in the Case of Prolonged Peroral Administration. AEC-tr-7013; Part of Radiobiology, (p. 161-171), 232 p.; Radiobiologiya, 8(6), 900-907.

The distribution in the internal organs, resorption in the gastrointestinal tract, and kinetics on the accumulation of a citric acid solution of plutonium administered perorally daily at doses from 0.01 to 10 uCi per day were investigated in experiments on 337 rats. It was established that the resorption of the isotope in the intestines does not depend on the amount introduced and comprises 0.058-0.066 percent. Of the resorbed amount in the skeleton, 71-83 percent is retained in the skeleton, 10.4-20 percent in the liver, 2.5-6.5 percent in the kidneys, and 2.2-7.6 percent in the lungs. The distribution of the isotope in the internal organs is diffuse, while in the lumen of the gastrointestinal tract it is diffuse and in the form of "stars" from the tracks of alpha particles corresponding to fragments of plant cells of food masses. The sites of the "stars" are situated on the surface of the mucous membrane of the GI tract. In areas of erosion and deep ulcers in the GI tract, primarily in the pharynx and cecum of a large number of aggregates of Pu is distributed over the entire damaged surface. The accumulation of plutonium in the internal organs is described by an exponential function and for the skeleton takes the form R=0.0478 x t(E-0.878), while the radiation dose rate increases during the entire life of the animal. In the large intestines, the dose rate is practically unchanged during the period from the first to 600th day. (Auth) (FMM)

<42>
Buldakov, L.A., L.G. Filippova, and G.V. Khalturin, Ministry of Health, Institute of Biophysics, Moscow, USSR. 1972

The Rate of Plutonium 239 in the Case of Subcutaneous Injection

The behavior and microdistribution of plutonium 239, injected subcutaneously, in the hexa and tetravalent monomer forms and the tetravalent polymer form were studied in experiments on guinea pigs. It was shown that T sub off of plutonium in the hexa and tetravalent monomer forms and tetravalent polymer form for the slowly exchanged fractions is 86, 80, and 1220 days, respectively. The main site of deposition of the absorbed plutonium is the liver and skeleton. A decrease in the activity of hexa and tetravalent monomer plutonium in the liver occurs with T sub off 39.5 and 79.5 days, respectively, while for plutonium of the tetravalent polymer form it occurs with T sub off=240 days. The activity of the isotope in the skeleton decreases with a period of 134 days. The microdistribution of the introduced plutonium compounds in the skeleton is monotypic; in the liver the hexavalent and tetravalent monomers are distributed diffusely, while the polymer forms dense "stars" of tracks of alpha particles. (Auth) (Complete text)

This manuscript is deposited in VINITI as No. 3639-71 Dep from October 26, 1971.

<43>
Buldakov, L.A., E.R. Lyubchanskii, Yu.I. Moskalev, A.P. Nifatov, A.A. Horvath (Translator), and R.G. Thomas (Ed.), Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1970, June

Problems of Plutonium Toxicology. LF-tr-41, 225 p.

This book contains a summarization, systematization, and analysis of the published data relating to the toxicity of plutonium. The principal areas discussed are physical and chemical properties of Pu 239, distribution of Pu 239 in the body after various routes of administration, biological effects of Pu following various routes of administration and the basis for setting the maximum permissible limits of Pu 239 in the human body, air and water. Four-hundred and twenty references are listed. (RAF)

<44>
Buldakov, L.A., Yu.I. Moskalev, and V.N. Strel'tsova, 1961, December; 1961, November

Observations on the Biological Action of Plutonium 239. Bulletin of Experimental Biology and Medicine, 52(7), 1277-1280; Byulleten Eksperimental'no: Biologii i Meditsiny, 52(11), 57-61.

White rats weighing 182 g were given

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<44> CONT.
intraperitoneal injections of plutonium citrate at pH 6 in amounts of 0.00125, 0.0025, 0.005, 0.01, 0.02, and 0.08 uCi/g. The effects of plutonium 239 on the life span, weight and peripheral blood as well as on the development of bone tumors was investigated. Time-effect and dose-effect curves were traced and their relationship with the life span, body weight, erythrocyte and leucocyte count was established. According to the life span criterion, the action of Pu was of a threshold character. The maximal noneffective dose of Pu was equal to 0.0025 uCi/g. With the administration of Pu in a dose of 0.0025-0.005 uCi/g a brief erythrocytosis was found, subsequently followed by stabilization of the number of erythrocytes at the initial level. When Pu was given in higher doses an anemia leading to the death of the animal developed by the 14th-30th day of the experiment. Leukopenia occurring as a result of Pu administration was irreversible. The incidence of osteosarcomas was 3.1-27.2%, and was about the same in males and in females. (RAF)

Tabular data are given on mean survival time of rats and on the incidence of osteosarcomas. Changes in the number of leucocytes and erythrocytes at different time intervals after Pu injection are shown graphically.

<45>
Bustad, L.K., K.A. Stitzel, E.K. Haro, and M. Goldman, University of California, Radiobiology Laboratory, Davis, CA. 1972

The Choice of the Beagle for Radiobiologic Studies. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 203-212), 552 p.

Originally chosen for widespread experimental use on the basis of caretaking, anatomic, and physiologic considerations, the beagle has proven to be an excellent model for sytemic studies whose results may be applied to man. There are numerous parallels among the late systemic effects of internally deposited emitters and of external radiation to the beagle and man, and the breed is making worthwhile contributions in several areas: in radionuclide toxicity, as a model in the scaling of the effects of alkaline earth radionuclides on bone and bone marrow and blood, in respiratory physiology, as a model for the pulmonary effects of inhaled radionuclides; in reproduction, where it is of special value in estimating the effects of fetal and neonatal irradiation. The extensive baseline data acquired over the past 20 years should enable useful extrapolations to be made from beagle to man on the natural processes involved in aging as well as on radiation-induced alterations, particularly oncogenesis. Established corollaries between canine and human ages provide a useful template for the scaling of dose-response over time, essential to quantitating the effects of low-level, long-term exposure to radiation and to evaluating possible risks to human populations. (Auth)

<46>
Cable, J.W., V.G. Horstman, and L.K. Bustad, Hanford Atomic Products Operation, Richland, WA. 1961, January 15

Effects of Intradermal Injections of Plutonium. HW-72500; Part of Kornberg, H.A. and Swezea, E.G (Eds.), Hanford Biology Research Annual Report for 1961, (p. 50-51), 180 p.

Eight blond miniature swine, six being held for lifetime observations, were injected intradermally with doses of 0.0016 to 5 uCi plutonium nitrate at various sites on the lateral thoracico-abdominal region. The quantity of plutonium detected by external monitoring of the sites injected with the three highest dose levels varied from 98 per cent at one day to less than 2 per cent after 565 days. A considerable variation in the degree and duration of the gross pathology, e.g., inflammation and size of ulcer, occurred between similar sites among animals. (Auth)

<47>
Catsch, A., Nuclear Research Center, Institute of Radiobiology, Karlsruhe, German Federal Republic. 1961

Radioactive Metal Mobilization. Federation Proceedings, 20, 206-219.

The mechanism of action and effectiveness of various chelating agents is described. Dimercaptopropanol (BAL) was ineffective against radiometals of practical interest, with the exception of Po 210. Radioyttrium and Pu respond fairly well to EDTA but there is marked dependence on the time of administration. The significance of relative chelate stability is pointed out as in the case of 1,2-diaminocyclohexanetetraacetic acid (CDTA) which has substantially higher stability constants than EDTA for most metal ions, but only slightly different relative stabilities. Its biological effectiveness is thus comparable to EDTA and not superior in tests done with Pu, radiocerium and radioyttrium. Results from experiments with rats show the considerable differences in effectiveness between EDTA and DTPA, the latter being more effective in retention studies with Y 91, Ce 144, Th 234, Pu 239, Fe, Cr, Co, Zn, Mn and U. The higher homologue of DTPA, ten-dentate triethylenetetraminehexaacetic acid (TTHA), when administered early, inhibits deposition of radiocerium, and radioyttrium in the skeleton much more than DTPA. In experiments on the influence of chelating agents in the acute toxicity of uranyl nitrate it was seen that when a single dose of the chelating agent was administered early, the LD 50 of U was increased from 6.7 mg/kg to 12.4 mg/kg by EDTA and to 16.2 mg/kg by DTPA. However, the toxicity of TTHA was 100% lethal to U injected animals within one hour of administration. In the case of radiostrontium, DTPA proved to be just as ineffective as EDTA. The greatest reduction in radiostrontium deposition in the skeleton has been obtained with Diamond Fast Blue, but since this dyestuff in effective doses has proved strongly toxic and sometimes lethal, it has no practical importance. The role of the kidneys in the effectiveness of chelating agents is discussed and experiments with nephrectomized animals are described. DTPA causes a marked increase of radiometal excretion in the fetus also, especially in the case of those, which like radiocerium, are deposited to a large extent in the liver. The differences in the extent to which the radiometal in the liver and skeleton can be depleted by DTPA were shown for Pu. daily administration of DTPA over 2 weeks reduced the Pu content of the liver to 3% of the control, while that of the skeleton fell to 50%. It is suggested that the effectiveness of DTPA is due to its penetration into the intracellular space, particularly in the liver, and it is expected that if this

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<47> CONT.
process were intensified, there would be a corresponding increase in effectiveness. The question of DTPA toxicity is discussed briefly. (FMM)

Table 1 shows effect of CaNa3-DTPA and CaNa2-EDTA on retention of different radioactive metals (Y 91, Ce 144, Th 234, Pu 239, Am 241) in rats. Table 2 shows effect of sodium polyphosphate on retention of Y 91, Ce 144 and Pu 239 in rats.

<48>
Catsch, A., Nuclear Research Center, Institute of Radiobiology, Karlsruhe, German Federal Republic. 1963

Toxicology: Radioactive Metals. Annual Review of Pharmacology, 3, 243-266.

A review is given of the toxicity of internally deposited radioactive metals. The behavior of a given radiometal in the organism can ultimately be explained by certain chemical, particularly coordination-chemical and ion exchange processes. An exact mathematical formulation of retention and excretion of a radionuclide is of great practical importance in so far as it is a requisite for the calculation of MPC values. The temporal distribution of the radiation dose seems to have difference importance for radiations with different LET. A quantitative analysis of radiotoxicity requires a determination of the radiation doses which accumulates in the organ after administration of a given amount of radionuclides. In this, knowledge of the retention functions as well as the microscopic distribution in the organ is needed. Possibilities of therapeutic treatment are mentioned, the most promising being the use of chelates. Sections are devoted to individual radiometals including the transuranic elements, the rare earths and yttrium, thorium, polonium, the alkaline earths, and miscellaenous metals (Ir 192, Ca 137, In 114, Zn 65, Pu 106, Zr 96, Co 60). For the transuranic, the metabolic behavior of Am 241 in rats is compared with Pu 239. There is faster removal of Am 241 from the liver and reduced initial deposition in the skeleton. Several experimental results are cited. About 20% of an inhaled Pu 239 PuO2 aerosol with a mean particle size of 0.2 u was retained by lung of mice. Using experimental data the MPC for man is computed as 1.6 x 10(E-10) uCi/ml air compared to the value of 4 x 10(E-11) uCi/ml recommended by the ICRP. Concerning the dependence of Pu 239 toxicity upon the dose rate, it is reported that single doses are significantly more effective than fractionated ones in the induction of hematological reactions, and the reduction of the life-span in rats. The therapeutic effectiveness of EDTA and DTPA in man following contamination by Pu 239 is reported. (FMM)

<49>
Catsch, A., Nuclear Research Center, Institute of Radiobiology, Karlsruhe, German Federal Republic. 1962

Principles and Trends in Therapeutic Removal of Internally Deposited Radionuclides. Health Physics, 8, 725-730.

The general principles governing the therapeutical removal of radiometals by chelating agents are outlined. Experimental data are presented demonstrating the dependence of chelate effectiveness on the number and the nature of ligand atoms as well as on the molecular configuration of the ligand. Implications derived from experimental data and from the multicompartmental nature of a body organ for working out an optimal dosage schedule are discussed. Several experimental results are discussed, for example, those dealing with the effectiveness of chelating agents (EDTA, DTPA, TTHA and TPHA) on retention of Y 91, Ce 144 and Th 234 in rats when treatment is early or delayed. The effectiveness of multiple chelate doses is also discussed and experiments cited, among them studies on the removal of monomeric Pu 239 by multiple DTPA doses (500 mg/kg) from liver and skeleton of the mouse. The effect of esterified polyaminoacids is also briefly discussed. (Auth) (FMM)

Figure 6 shows removal of monomeric Pu 239 by multiple DTPA doses (500 mg/kg) from organs of the mouse. Figure 1 shows effect of EDTA, DTPA TTHA, and TPHA on the retention of radiometals (Y 91, Ce 144 and Th 234) by organs of the rat. The calcium chelates (250 uM/rat) were administered a few minutes post-injection (early treatment) or on the third day (delayed treatment.)

<50>
Chipperfield, A.R., and D.M. Taylor, Institute of Cancer Research, Department of Biophysics, Sutton, Surrey, England. 1970

The Binding of Americium and Plutonium to Bone Glycoproteins. European Journal of Biochemistry, 17, 581-585.

By means of a gel filtration technique it is shown that plutonium and americium differ in their mode of binding to two glycoproteins isolated from bovine cortial bone. Plutonium binds more strongly than americium. Plutonium binding is maximal at pH 6 and americium at pH 8, and sialic acid is involved in the binding of plutonium but not americium. The mechanisms by which these elements bind to glycoproteins in vitro are discussed. (Auth)

<51>
Christensen, W.R., W.S.S. Jee, G.N. Taylor, and N. Nebeker, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

Distribution of Internal Radiation-Induced Osteogenic Sarcoma in Various Species. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 195-202), 552 p.

The localization of osteogenic sarcoma varies markedly from species to species, whether occurring as a "spontaneous tumor" or as a result of an internally-deposited, bone-seeking radionuclide. In humans the spontaneous tumors showed an unusual predilection for the region of the knee joint. Ra 226-induced tumors in humans are located primarily in the appendicular skeleton (90%), but there are relatively few at the knee joint. The most common site is the pelvis. In dogs 60% of the radiation-induced tumors were found in the appendicular skeleton, whereas in mice only 25% of such tumors were so located. The most common site in the mouse is the vertebral column. In the case of both dogs and mice the distributions of Pu 239 and Ra 226-induced osteogenic sarcoma were quite

<51>

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<51> CONT.
dissimilar. (Auth)

Table 1 and Table 2 give the distribution of spontaneous osteogenic sarcomas in humans. Table 4, 5 and 6 give the distribution of osteogenic sarcomas in dogs. Table 7 and 8 give the distribution of osteogenic sarcomas in mice.

<52>
Clarke, W.J., and W.J. Bair, Hanford Atomic Products Operation, Hanford Laboratories, Richland, WA. 1964, January 15

Pathologic Effects of Inhaled Plutonium Particles. HW-80500; Part of Kornberg, H.A. and Swezea, E.G. (Eds.), Hanford Biology Research Annual Report for 1963, (p. 42-43), 259 p.

Inhalation of Pu 239 PuO2 particles by beagle dogs produced death within 55 to 855 days in animals having lung burdens of 2 to 27 uCi. Deaths were preceded by a progressive lymphopenia and respiratory distress. Deposition of the particles in the lungs was followed by substantial translocation to the bronchial and mediastinal lymph nodes. Pulmonary lesions consisted primarily of severe fibrosis followed by metaplasia. Although primary lung carcinoma had not been observed, many of the changes that had occurred were similar to those found in those neoplasms. (Auth) (FMM)

Table 1 shows time of death and body burden data in beagles inhaling Pu 239 PuO2 particles

<53>
Clarke, W.J., J.R. McKenney, V.G. Horstman, L.J. Seigneur, J.L. Terry, and L.K. Bustad, Hanford Atomic Products Operation, Richland, WA. 1959, January 5

Plutonium Metabolism in Miniature Swine. HW-59500; Part of Davis, J.J. (Ed.), Hanford Biology Research Annual Report for 1958, (p. 54-60), 156 p.

The blood uptake, tissue concentration, body burden and excretion pattern of plutonium, variously administered, were studied in fourteen yearling miniature swine of the Hormel strain, initially averaging 70 kg in body weight. By the intravenous route, 5 uCi of Pu 239 were administered in the form of Pu (+4) citrate at pH 6.0, by the intratracheal route, the dose was 30 uCi as Pu(+4) Nitrate at pH 2.5, and by the intragastric route, 600 uCi were administered as (Pu(+4) nitrate at pH 2.0. It was shown that the percentage of administered dose of Pu 239 retained by the adult miniature swine at 600 days was about 20,000 times greater after intravenous than after intragastric administration. The plutonium showed a higher concentration in liver than in bone, regardless of path of entry. The elimination rate of the isotope was dependent on route of administration, being slowest after intravenous dosing. (Auth) (FMM)

Table 3 shows concentration of Pu 239 in liver and bone at 30 and 600 days after administration.

<54>
Clarke, W.J., J.F. Park, J.L. Palotay, and W.J. Bair, General Electric Company, Biology Laboratory, Richland, WA. 1964, June 29

Bronchiolo-Alveolar Tumors of the Canine Lung Following Inhalation of Plutonium Particles. American Review of Respiratory Diseases, 90, 963-967.

Inhalation of plutonium particle caused spontaneous deaths at 55 to 1,446 days after exposure in beagle dogs having a lung burden of 0.6 to 48 uCi PuO2. Four dogs surviving more than 1,150 days and one animal that died 150 days following exposure to high levels of plutonium aerosols showed bronchiolo-alveolar tumors. Although most of these neoplasms were locally invasive, and some appeared to be of multicentric origin, no evidence of regional or distal metastasis was seen. The progression sequence of tumor formation appeared to be desmoplasia, metaplasia, and, finally, neoplasia. (Auth)

Mortality and dose statistics, and distribution of Pu (% of body burden) are given in tabular form.

<55>
Clarke, W.J., J.F. Park, J.L. Palotay, and W.J. Bair, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1966

Plutonium Inhalation Studies. 7. Bronchiolo-Alveolar Carcinomas of the Canine Lung Following Plutonium Particle Inhalation. Health Physics, 12, 609-613.

Inhalation of Pu 239 PuO2 particles (with count median particle diameter ranging from 0.1 to 0.5 micro) by forty beagle dogs caused spontaneous death in ten animals having lung burdens of from 0.5 to 2.0 uCi. Deaths occurred at 29 to 56 months post-exposure. The pathologic effects observed in the lungs of these animals consisted primarily of severe fibrosis followed by alveolar cell hyperplasia, and bronchiolar and squamous types of metaplasia. Five of the animals showed bronchiolo-alveolar carcinomas, an incidence of 13 per cent as compared to a primary lung tumor incidence of 0.2 per cent in canine necropsy material. All neoplasms originated in peripheral lung areas in association with particle retention, fibrosis, and bronchiolo-alveolar metaplasia. The irradiated, proliferating cells, comprising the hyperplastic and metaplastic response to lung scarring, appeared to be the nidus of tumor formation. Metastases were seen in one dog. (Auth)

Table 1 shows body burden and distribution of Pu in tissues (lung, lymph nodes, liver and bone) of dogs.

<56>
Cole, K.S., University of Chicago, Health Division, Chicago, IL. 1945

Biological Research Section. CN-3190; Part of Report of Health Activities for Month of July, 1945, (p. 2-4), 17 p. (Declassified December 15, 1955)

A progress report is given on several research projects. Dogs given single and daily doses of total body x-rays showed a 75-100% increase in the P fraction of adenosine triphosphate-hexosephosphate. New methods of producing aerosols efficiently are being investigated. Some results are given on the biological effects of Zr 93-Cb 93, and Y 92 injected into rats, Sr 89 injected into mice, and plutonium nitrate injected into a mouse. Hematological studies were carried out on rats previously given Pu. Methods are being investigated to determine the amount of Pu in large amounts (1-2 liters) of urine from project personnel. An ongoing research

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<56> CONT.
project deals with the biologic action of x and gamma rays on mice, guinea pigs and rabbits. Pathological and hematological findings are given. (PAP)

<57>
Cole, K.S., University of Chicago, Chicago, IL. 1945, December 15

Biological Research Section. CN-3358; Part of Jacobson, L.C., et al, Report of Health Activities for Month of November, 1945, (p. 3-7), 7 p. (Declassified January 18, 1956)

The absorption of ingested Pu was studied in six rats that were given given plutonium by stomach tube as the plus 4 nitrate at a concentration of about 0.5 mg per ml and at a pH of about 2. The actual dose was about 4.7 micrograms/g. The rats were sacrificed at intervals following ingestion and two femurs from each of five of the rats were ashed and analyzed. The femurs contained from 2.9 to 8.4 x 10(E-5) percent of the dose. Multiplication of the femur by 30 gave a figure for the entire skeletor of from 8.7 to 25 x 10(E-4) percent of the dose. The results showed that the plus 4 nitrate given orally to rats at a level of 4.7 micrograms per gram was absorbed from the gastrointestinal tract in an amount not over 3 x 10(E-3) percent. In another experiment, the hematological effects of Pu were studied in ABC male mice that were given 0.25 microgram/g of plutonium. The hemoglobin level showed a moderate, progressive reduction that reached its lowest point at 25 weeks. Erythrocyte counts showed a 10 to 15 percent reduction that persisted throughout the 40 weeks of the experiment. The heterophil value also showed an immediate reduction that reached its maximum depression at 8 weeks. Recovery followed rapidly after this point, however, and the heterophil counts were above those of the controls at 32 weeks. It was concluded that recovery occurred in the heterophil count in spite of continuous irradiation, but that no recovery occurred in the red cell and lymphocyte counts. (PMM)

Table 1 shows absorption of orally administered Pu by rats.

<58>
Cole, K.S., J.J. Nickson, and J.G. Hamilton, University of Chicago, Metallurgical Laboratory, Chicago, IL. 1944, August 17

Monthly Report on Problems Relating to Product for Period Ending July 31, 1944. CN-1990; 6 p. (Declassified January 2, 1952)

The monthly progress report updates work being performed at the Metallurgical Laboratory and University of California Radiation Laboratory. work in the biological research section is continuing with studies of distribution of Pu in rats after Pu Cl4 aerosol inhalation excretion and toxicity of Pu Cl4 in rabbits, rats, and mice, and radium experiments. The Medical Industrial Hazard Section reported an surveys of personnel and facilities for radiation contamination. Continuation of studies by the University of California Radiation Laboratory are reported on radioautographic studies, tracer studies, and decontamination studies. (BBM)

<59>
Cole, K.S., J.J. Nickson, and J.G. Hamilton, University of Chicago, Chicago, IL. 1944, July 14

Monthly Health Report on Problems Relating to Product for Period Ending June 30, 1944. CN-1910; 5 p. (Declassified February 14, 1956)

The monthly health reports from Clinton Laboratory updates work in progress at the Metallurgical Laboratory and the University of California Radiation Laboratory. The biological research section covers work being done on aerosol production, Pu Cl4 aerosol exposure studies on rats, and analytical recovery of the product from tissues. The Medical Industrial Hazard Section reported on surveys of radiation and contamination of facilities and personnel. Reports on metabolic studies of plutonium are updated for radioautographic studies and tracer studies on animals. (BBM)

<60>
Craig, D.K., R.L. Buschbom, and J.P. Herring, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1972, September

Relationships Between the Size Distribution of Plutonium 239 PuO2 Aerosols, Aerosol Concentration, and Nebulizer Suspension Concentration. BNWL-1650 (Part 1); Part of Thompson, R.C. (Ed.), Annual Report for 1971, (p. 178-189), 313 p.

In a study of low level effects of inhaled Pu 239 PuO2 in beagle dogs, alveolar burdens over the 1500-fold range from 2 nCi to 3 uCi were deposited inunanesthetized dogs by aerosol inhalation. Aerosols were generated by nebulizing magnetically stirred suspensions of Pu 239 PuO2 particles in water; the aerosol concentration (CONC) being varied, primarily, by changing the Pu concentration of the suspension (SSA). If the mass concentration of the suspension was kept below about 10 mg (540 uCi) PuO2/Ml, a good correlation (R=0.827 for n=64) was observed between CONC and SSA with constant air flow through the exposure chamber. SSA values from 1 to 600 uCi/ml gave CONC values in the range 1.5 to about 3000 nCi/l. However, the aerodynamic equivalent size distribution also varied significantly with CONC. The activity median aerodynamic diameter (AMAD) increased from about 1.5 to 3 um as CONC increased (R=0.786 for n=64), while the geometric standard deviation (GSD) decreased (R=0. 576 versus AMAD). These observations help to explain the large variation observed in the percentage alveolar deposition of inhaled Pu 239 PuO2 aerosols from less than 1% to nearly 50% in 64 dogs for which the are thus far available. A change in AMAD from 1.54 um (GSD 2.61) to 2.77 um (GSD 1.61) decreased the percentage of Pu 239 activity in particles having aerodynamic equivalent diameters less than 1 um from 32.63 to 1.62. This effect on particle size is the major factor determining percentage alveolar deposition. (Auth)

<61>
Crowley, J., H. Lang, K. Scott, and J.G. Hamilton, University of Chicago, Chicago, IL. 1946, May 31

A Comparison of the Metabolism of Plutonium (Plutonium 238) in Man and the Rat. CH-3589; 16 p. (Declassified November 21, 1956)

The fate of plutonium injected intravenously into a human subject and into rats was followed in parallel studies. The

<61>

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<61> CONT.
distribution of plutonium among the tissues of the body and the average daily rate of excretion of this element were compared in man and rats. In general, the results of these experiments showed a high degree of prolonged retention of plutonium in the body, with selective deposition in the skeleton, especially in the region adjacent to the bone marrow in the endosteum and trabecular bone. The elimination of plutonium from the body occurs at higher rates in rats than in man. During the course of these studies, rats eliminated 50% of the plutonium administered, whereas in the parallel experiment in man, only about 5% was excreted. The elimination of plutonium was primarily in the feces in rats, and in man the major elimination of plutonium occurred via the urine. (Auth)

<62>
Dagle, G.E., Colorado State University, Fort Collins, CO. 1973, August

Lymph Node Clearance of Plutonium from Subcutaneous Wounds in Beagle. COO-1787-18; Ph.D. Thesis, Colorado State University; 127 p.

The lymph node clearance of plutonium oxide from subcutaneous implants was studied in adult beagles to simulate accidental contamination of hand wounds. External in situ scintillation data were collected from the popliteal lymph nodes of each dog after 9.2 to 39.4 uCi of plutonium oxide was subcutaneously implanted into the left or right hind paws. The left hind paw was amputated 4 weeks after implantation to prevent continued deposition of plutonium oxide particles in the left popliteal lymph node. Groups of 3 dogs were sacrificed 4, 8, 16, and 32 weeks after plutonium implantation for histopathologic, electron microscopic, and radiochemical analysis of regional lymph nodes. An additional group of dogs received treatment with the chelating agent diethlenetriaminepentaacetic acid (DPTA). Plutonium rapidly accumulated in the popliteal lymph nodes after subcutaneous injection into the hind paw, and 1% to 10% of the implant dose was present in the popliteal lymph nodes at the time of necropsy. Histopathologic changes in the popliteal lymph nodes with plutonium particles were characterized primarily by reticular cell hyperplasia, increased number of macrophages, necrosis, and fibroplasia. Eventually, the plutonium particles became sequestered by scar tissue that often replaced the entire architecture of the lymph node. Light microscopic autoradiographs of the popliteal lymph nodes showed a time-related increase in number of alpha tracks per plutonium source. Electron microscopy showed that the plutonium particles were aggregated in phagolysosomes of macrophages. There was slight clearance of plutonium from the popliteal lymph nodes of dogs monitored for 32 weeks. The clearance of plutonium particles from the popliteal lymph nodes was associated with necrosis or macrophages. The external iliac lymph nodes contained fewer plutonium particles than the popliteal lymph nodes and histopathologic changes were less severe. The superficial laguinal lymph nodes of one dog contained appreciable amounts of plutonium. Treatment with DTPA did not have a measurable effect on the clearance of plutonium from the popliteal lymph nodes. (Auth)

<63>
Debois, J.M., Saint Raphall University Clinic, Lounain, Belgium. 1966

The Metabolism of Transuranium Elements. Bulletin d'Information de l'Association Belge pour le Development Pacifique de l' Energie Atomique, 11(60), 13-17; ORNL-tr-1463; 13 p.

A review is given of the toxicity and general characteristics of the metabolism of the transuranium elements with emphasis on plutonium. Elements briefly discussed are americium, curium and californium. The detailed discussion of plutonium deals with general characteristics, permissible body burden, absorption, inhalation, injuries, findings in man, and long-term effects, particularly in the skeleton. Decontamination methods in case of accidental exposure to transuranics are mentioned. (RAF)

<64>
DeBruyn, P.P.H., Not given. 1948

Lymph Node and Intestinal Lymphatic Tissue. Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 8. McGraw Hill Book Company, Inc., New York, New York, (p. 348-445), 808 p.

The damage in the lymph node of animals exposed to x-rays is correlated with the amount of radiation. This correlation is seen in the amount of debris resulting from the destruction of lymphocytes, but is particularly marked in the changes of the lymphatic nodules. In rabbits, doses of 800 and 600 R completely destroy the great majority of nodules, resulting in a "nodule-free" period until about 3 weeks after treatment, at which time new nodules begin to form. Since the LD 50/30 days of x-rays for rabbit, rat, and guinea pig are approximately 800, 600, and 175 R, respectively, it appears that the intensity of damage is relatively independent of the LD 50/30 days value. Both fast and slow neutrons produce histologically the same changes in the lymph node as do x-rays. The changes produced in the lymph node by internally administered radioactive materials are histologically the same as those produced by externally applied radiations. Fission-products mixture, administered to rats in doses of 23 and 33 uCi/g by gavage, completely destroyed the nodules in the mesenteric lymph node. Strontium 89 administered intraperitoneally to mice produced mild changes in the reticular cells after 3.6 uCi/g. A dose of 14.5 uCi/g caused complete destruction of the nodules. Sodium 24 administered intraperitoneally in mice in doses varying from 47 to 83 microcuries / gram caused complete destruction of the nodules of the lymph node. No nodules were found in the lymph nodes of rats injected intracardially with zirconium 93-niobium 93 in doses ranging from 3.0 to 7.0 uCi/g. In rats injected intraperitoneally with radium in doses ranging from 0.02 to 0.5 uCi/g, there was after two to six months a correlation between the number of lymph nodes with nodules and the dose. The intravenous injection of 0.08 uCi/g of plutonium, or the intramuscular injection of 0.1 uCi/g produced in the lymph nodes of mice only moderate nuclear and cytoplasmic damage to lymphocytes. Lymphopoiesis was not affected. Plutonium injected intravenously into rats in doses of 0.125 and 0.06 uCi/g completely destroyed the lymphatic nodules. With the exception of zirconium 93-niobium 93 and plutonium, the internally applied radiations had the same effects in the intestinal lymphatic tissue as

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<64> CONT.
in the lymph node. Following these two agents there were minor quantitative differences in the reaction of the two tissues. (Auth) (FMM)

Numerous histological sections are shown.

<65>
Dedrick, M., M.R. Sikov, and D.D. Mahlum, Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA. 1973, July

Distribution and Effect of Plutonium 238 in the Fetoplacental Unit of the Rat. CONF-730431; Part of Proceedings of the 21st Annual Symposium of the Radiation Research Society held in St. Louis, Missouri, April 29-May 3, 1973. Published in Radiation Research, 55(3), 515.

The distribution of heavy metals within the fetoplacental unit (FPU) of the rat shows a typical pattern, although differences relating to the specific material, physicochemical state, and stage of gestation are apparent. Doses of Pu 239 as low as 3uCi to the dam have a pronounced embryocidal effect when administered at 9 days of gestation, although 50 uCi is not lethal at 15 or 19 days. The present study with Pu 238 was undertaken to evaluate the effect of specific activity on the distribution and toxicity of plutonium in the prenatal rat. Pregnant rats were intravenously injected with graded doses of citrated Pu 238 solution after 9 days of gestation and killed 5 days later. The components of the FPU were weighed, examined, and subjected to radioanalysis and autoradiography. Mortality was in the same range as found with Pu 239, being 40% after a dose of 6 uCi to the dam with a further increase at doses of 7.5 uCi and above. Other animals were injected with 3 uCi Pu 238 after 15 or 19 days of gestation, killed 24 hours later, and the distribution of activity determined. The pattern of relative concentrations was similar to that found with other heavy metals: marked accumulation in the membranes (particularly the yolk sac), less in the placenta, and least in the conceptus, suggesting that specific activity does not influence partition. (Auth) (Complete Article)

<66>
Dockum, N.L., and W.S.S. Jee, University of Utah, College of Medicine, Salt Lake City, UT. 1966, March 31

Effect of Daily Injections of Plutonium 239 on Rat Bones. COO-119-234; Part of Dougherty, T.F., Reserach in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 180-190), 326 p.

Rats were administered 0.5 uCi of Pu 239 intraperitoneally daily for 7, 6, 5, 4, and 3 days followed by from 1 to 5 days rest. H 3-thymidine was administered intraperitoneally to some of the groups one hour prior to sacrifice at 8 days. Another group received 7 intraperitoneally injections of Pu 239 and after 58 additional days was administered H 3-thymidine one hour prior to sacrifice. Control animals were given H 3-thymidine at the same time, namely at 65 days. The parameters investigated included total osteoblasts per unit area, trabecular perimeter, osteoclasts and osteoblasts per millimeter of trabecular surface. Following Pu 239 administration it was found that the mesenchymal cell population tended to favor the formation of osteoclasts rather than osteoblasts in both the short-term and long-term experimental animals when they were compared with the controls for the same time period. (Auth)

<67>
Dougherty, J.H., University of Utah, Radiobiology Laboratory, Salt Lake City, UT. 1960

Comparison of Effects of Lethal Body Burdens of Plutonium 239 and Radium 226 on Hematopoiesis in Beagles. Radiation Research, 12, 431.

The blood picture was followed at monthly intervals in ten adult beagles given a single intravenous injection of an average of 10.4 micro Ci/kg of Ra-226 and nine dogs given an average of 2.88 micro Ci/kg of Pu-239 intravenously. Comparisons were made to similar data in twenty four control animals. The skeletal dose rates to the radium dogs are approximately 2.5 times that to the plutonium dogs at one year. However, due to differences in the radionuclide distribution in bone this does not accurately reflect bone marrow dose. The average survival time was 1046 days for radium injected dogs and 1338 days for the plutonium group. There were eight bone tumors in the radium group and three bone tumors in the plutonium group. The detailed hematological findings for all groups will be presented. No tumors of hematopoietic origin were found. Despite differences in radionuclide distribution, tumor incidence, survival time and amount and distribution of skeletal damage between the two groups of dogs, the degree and time sequence of depression in blood cell elements and hematological findings at time of death were remarkably similar. (Auth) (Complete Article)

<68>
Dougherty, J.H., University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

The Hematologic Changes Induced by Plutonium 239 in Beagles. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 75-86), 552 p.

The hematologic changes following a single intravenous injection of a wide range of doses of Pu 239 (0.016-2.8 uCi/kg) in young adult beagles have been followed over the lifespan of the animals. This study has been underway for 20 years. All of the dogs in the original 12 injection groups have died, the main cause of death being osteosarcoma. Blood cells alterations were found in dogs receiving the four highest dose levels. The changes were dose-dependent and were most marked in granular leukocytes which were maximally depressed at 2 to 3 weeks post-injection. A sustained lymphopenia occurred at the two highest dose levels. A transient early thrombocytopenia and anemia were also found in higher level dogs. A moderate anemia reappeared as the animals became terminal. There was myeloid metaplasia in spleens and livers of dogs at autopsy. The hematologic changes found after Pu 239 injection were compared to several other internal emitters (Ra 226, Th 228, Ra 228 and Sr 90). The bone-surface seekers, Pu 239 and Th 228, were found to be the most damaging to the hematopoietic system. (Auth)

Table 1 gives peripheral blood findings on 5-level Pu dogs. Table 2 gives bone marrow M/E

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<68> CONT.
ratios in 5-level Pu dogs.

<69>
Dougherty, J.H., J.Z. Bowers, R.C. Bay, and P. Keyanonda, University of Utah, College of Medicine, Radiobiology Division, Salt Lake City, UT. 1955, July-December

Comparison of Hematologic Effects of Internally Deposited Radium and Plutonium in Dogs. Radiology, 65, 253-259; Part of Proceedings of the 40th Annual Symposium of the Radiological Society of North America held in Los Angeles, California, December 5-10, 1954, (7 p.).

Young adult male and female beagle dogs were injected intravenously five dose levels of Ra 226 and Pu 239 in the citrate form. The dose levels were estimated on a retained basis as 2.5, 0.81, 0.27 and 0.086 and 0.014 uCi/kg. Retained burden was estimated by total gamma counting, breath radon measurements, and urine and fecal assays. The hematologic determinations included hemoglobin, volume of packed red blood cells, red cell count, cellular indices, white cell count, direct eosinophil count, platelet count, sedimentation rate, reticulocyte count, and icteric index. No significant hematologic alterations have been observed during the first year in animals receiving 0.086 or 0.014 uCi/kg of Pu or Ra. A significant leukopenia developed in dogs which retained amounts of 0.27, 0.81 and 2.5 uCi/kg of Pu or Ra. There was no significant difference of leukocyte depression between Pu and Ra animals at comparable dose levels. Leukocyte numbers fell at all dose levels at 21 to 30 days, then increased during the next 30 to 60 days to reach a subnormal plateau. A depression in granular leukocytes was seen in the 0.27 uCi/kg dogs with lymphocyte values remaining within normal limits during the year of observation. A depression of lymphocytes was seen in animals receiving the two highest dose levels. A variable but significant depression in erythrocyte values was seen in dogs receiving the 2.5 uCi/kg dose of Pu. (RAF)

The dose-time relationships of leukocyte, heterophil, lymphocyte and platelet response to Pu and Ra are given in graphic form.

<70>
Dougherty, T.F., University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1962, March 31

Research on Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program. COO-225; 135 p.

Injection tables are given and explained for the chronic toxicity studies on dogs using the radionuclides Ra 226, Pu 239, Ra 228, Th 228 and Sr 90. Several related studies are reported and 8 of these have been abstracted separately for inclusion in the data base. The studies include anatomical distribution of radiation-induced fractures in beagles, an electrophoretic study of serum protein fraction in Ra 226 and Pu 239 injected dogs, pathologic and normal bone remodelling as visualized by radioautographic distribution of Pu, the long-term effects of Pu 239 in adult beagles and comparative toxicity of Ra 226, Pu 239, and Sr 90 in adult beagles. (FMM)

<71>
Dougherty, T.F., University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1960, March 31

Research in Radiobiology, An Annual Report of Work in Progress on the Chronic Toxicity Program. COO-220; 225 p.

Progress is reported for the various sections of the chronic toxicity program. The project is designed to obtain information on the influences of internally deposited radioisotopes on certain functions which occur during aging. Injection tables are presented for the toxicity and test animals used in the study with Ra 226, Pu 239, Ra 228, Th 228 and Sr 90. Eleven papers have been abstracted separately for inclusion in the data base. These include the distribution of the radionuclides in dog teeth and the histopathologic changes in teeth containing Pu, the effect of internally deposited radionuclides on the blood vessels of cortical bone, the localized distribution of Pu 239 in the lumbar vertebral centra of 5-level dogs and a case of bone tumor arising from the temporal bone. (FMM)

<72>
Dougherty, T.F., University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1960, September 30

Research in Radiobiology, Semiannual Report of Work in Progress on the Chronic Toxicity Program. COO-222; 140 p.

Progress is reported for the chronic toxicity program involving dogs injected with Ra 226, Pu 239, Ra 228, Th 228 or Sr 90. The injection tables are shown in tabular form and give the age and weight of the animals, injected dose, date injected and dose to the skeleton. Reports are included on 15 test radium dogs and on soft tissue tumor incidence in beagles with long-term internal radionuclide burdens. (FMM)

<73>
Durbin, P.W., Lawrence Radiation Laboratory, Division of Medical Physics, Berkeley, CA. 1960

Metabolic Characteristics Within a Chemical Family. Health Physics, 2, 225-238.

The available data have been reviewed for the biological behavior in rats of high specific-activity radioisotopes of seventy elements. Tracer quantities were administered in single intramuscular injections. Groups of rats were autopsied at various intervals, and tissues and excreta were assayed for radioactivity. Distribution data were arranged according to the grouping of the periodic table of the elements. The anions (including the halogens), the oxygenated or halogenated ions of Groups 4, 5 and 6, and the transition metals were rapidly eliminated by the kidney. The monovalent alkali metals were distributed almost uniformly in soft tissue with subsequent excretion by the kidney. The bivalent cations, except Hg(E+2), Cd(E+2) and UO2(E+2), were deposited primarily in bone mineral and were eliminated slowly in both urine and feces. The tripositive elements of Group 3, the lanthanides, and the actinides were deposited in liver and bone. The liver fraction was excreted via the bile without recirculation, while that deposited in bone was turned over at a rate slower than that of normal bone remodelling. The quadrivalent

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cations such as Zr(IV+VI), Th(IV+VI) and PuO2(IV+VI) were deposited almost exclusively in bone and were bound more strongly than the Group 3 elements. The properties that determine biological behavior are: (a) the oxidation state stable at body pH, (b) the solubility of the stable state, (c) the tendency to be incorporated into organic compounds, and (d) the tendency to associate with specific proteins. (Auth)

<74>
Ebner, H.G., and W. Schwartz, Dortmund University, Dortmund, Germany. 1973, October

Investigations on the Bacterial Leaching of Uranium Ores. Erzmetall, 26(10), 484-490.(German)

Basic principles of the process of bacterial leaching are covered. Experiments with uranium ores from deposits in the Federal Republic of Germany, using varieties of the thiobacillus, are described. Experimental results and optimization of leaching conditions are discussed. Another method combining chemical and microbiological leaching is described. (GW)

<75>
Elkina, N I., Not given. 1963

Phosphatase Activity and Content of Calcium, Phosphorus and Nitrogen in Rabbit Bony Tissue after Injury with Plutonium 239. AEC-tr-5436, Part of Radiobiology, (p. 32-36); Radiobiologiya, 3(3), 351-354.

Rabbits aged 180-240 days, weighing 2.5-3.0 kg, were administered plutonium nitrate intravenously at pH 2 at doses of 7 uCi/kg and 2 uCi/kg. The rabbits were sacrificed 3, 7, 14, 30, 135 and 180 days after the 7 uCi/kg and 135, 180 and 360 day after the 2 uCi/kg Pu injection. Bony tissue was analyzed for Ca, P, N and phosphatase activity. Separate investigations at diaphysical and epiphysical portions of tubular bones were carried out. The alkaline phosphatase activity in rabbit bony tissue at doses of 7 uCi/kg Pu decreased in the epiphysis and diaphysis. At doses of 2 uCi/kg Pu, the decrease of enzyme activity was noted only in the epiphysis. The content of calcium, phosphorus and total nitrogen in bones of experimental animals did not differ significantly from the control. (RAF)

<76>
Ellis, L.C., and D.L. Berliner, State University, Department of Zoology, Logan, UT, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1966

Internally Deposited Radionuclides and the Subsequent Alteration of Androgen Biosynthesis by Canine Testicular Tissue. CONF-660212; Part of Proceedings of the 14th Annual Symposium of the Radiation Research Society held in Coronado, California, February 13-16, 1966. Published in Radiation Research, 27, 549.

The data presented in this report were obtained from adult Beagle dogs which were sacrificed according to a prearranged schedule. These animals were part of the comparative study on the biological effects of some radionuclides in the basic program of the Radiological Division of the Department of Anatomy, University of Utah. The dogs were injected with the various radionuclides according to the project outline. Five animals were injected with 3.2 uCi/g of Ra 226, five animals received 0.016 uCi/g of Pu 239, three received 0.30 uCi/kg of Pu 239, five animals received 0.016-0.30 uCi/g of Th 228, two animals received 0.34 uCi/g of Ra 228, and one animal received 0.17 uCi/g of Sr 90. Four control animals were included for comparative purposes. Immediately after the animals were sacrificed, one-gram aliquots of the testes were minced and incubated with 5-pregnenolone-7 alpha-H 3 and progesterone-4-C 14. Isolation and quantification of the steroid intermediatesshowed that 5-pregnenolone was converted into 17 alpha-hydroxyprogesterone, androstenedione, and testosterone faster than was progesterone, as has been demonstrated by other workers. The conversion of the two androgen precursors into androstenedione, testosterone, and total androgens was markedly reduced for all of the injected animals. Thus, these data show that internally deposited radionuclides to diminish androgen biosynthesis in vitro as has been previously reported for the adrenal glands of dogs, and testes from mice and rats after the latter had received various modes of irradiation. (Auth)

<77>
Ellis, L.C., and D.L. Berliner, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1967, March 31

The Effects of Ionizing Radiations on Endocrine Cells. 6. Alterations in Androgen Biosynthesis by Canine Testicular Tissue after the Internal Deposition of Some Radionuclides. COO-119-236, Part of Dougherty, T F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 218-251), 268 p.

Male beagle dogs were injected intravenously with various radionuclides (Ra 226, Pu 239, Th 228, Ra 228 and Sr 90) when approximately 18 months of age. At various time intervals the testes were removed from the animals, and incubated with pregnenolone-7 alpha-H 3 and progesterone-4-C 14. The resulting steroid intermediates were isolated by paper chromatography and derivative formation. The pathways observed for the synthesis of androgens were essentially the same as those observed from perfusion studies by other workers. The 17-alpha-hydroxylation of progesterone was diminished in all but one animal, which had received Sr 90. Similarly, less androstenedione, testosterone, and total androgens were produced by the tissues from the treated animals as compared to the control group. Pregnanedione was isolated from the incubations of at least eight dogs. The occurrence of this compound with respect to fevers in treated animals was discussed. When a NADPH-generating system was added to incubation of tissues from both groups of animals, there was an increase in steriod biotransformations for both groups. Although the increase in muscles of testoterone and androstenedione production was greater for the control group after the addition of the cofactor-generating system, the percent increase in androstenedione, testosterone, and total androgen production was greater for the treated group. (Auth)

<78>
Frieksova, E.V., and A. Ferber (Translator), Israel Program for Scientific Translations,

<78>

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<78> CONT.
Jerusalem, Israel. 1969

Distribution of Plutonium 239 in the Animal Organism. AEC-tr-6982; Part of Erleksova, E.V., Distribution of Radioactive Elements in the Animal Organism (Polonium 210, Radiothorium 228, Plutonium 239, and Strontium 90), Atlas, (p. 112-144), 161 p.

For a study of the nature of Pu 239 distribution in the organism and its localization in tissues and organs, material was obtained from 286 white rats and 20 white mice for radioautographic examination. Pu 239 nitrate (0.9 1 cm 3 solutions at pH 6.4) was administered intraperitoneally. Activities of solutions were 0.15, 0.08, 0.04, 0.02, 0.01, 0.005, and 0.0025 mcl/kg. Twenty mice received 0.15 mCi/kg subcutaneously. Animals were sacrificed and organs and tissues were examined from 5 minutes to 578 days. Examination was made on the injection site, lungs, myocardium, hematopoietic organs, sex organs, bones, and in some animals, the nervous system. Acute radiation sickness develcped with 0.15 to 0.08 mCi/kg, the subacute form appeared with 0.04 to 0.02 mCi/kg; and at a later date, osteogenic sarcomas developed with 0.01, 0.005, and 0.0025 mCi/kg. Plutonium disappeared from the organs of all systems comparatively rapidly, even from the liver, with the exception of the skeleton where it was accumulated and retained for a very long time. Thus, the bones are the sites of development of the most severe pathological processes and tumors, such as osteogenic sarcoma, associated with the direct effect of an alpha emitter. (BBM)

<79>
Frokhin, R.A., N.A. Koshurnikova, E.R. Lyubchanskii, A.P. Nifatov, and G.N. Resetov, Not given. 1964

Levels and Microdistribution of Plutonium 239 in the Rat Lungs and Liver, and Morphological Changes in these Organs Following Intratracheal Administration of the Isotopes. AEC-tr-7590; Part of Moskalev, Yu.I. (Ed.), Distribution, Biological Effects, and Accelerated Excretion of Radioactive Isotopes, (p. 42-62), 405 p.

Plutcnium 239 was administered intratracheally to Wistar rats of both sexes weighing 140-160 grams in a dosage of 7 uCi/kg as the nitrate (pH 2) and the sodium plutonyl triacetate (pH 6.5). The animals were sacrificed after 20 minutes, 1, 6, 12 hours, 1, 3, 4, 8, 16 days and 1, 3, 4, 6 and 8 months. The behavior of plutonium in the lungs following intracheal administration of different salts thereof was determined primarily by the physicochemical form of the compound administered. a) the plutonium content of the lungs was 5-10 times higher after administration of nitrate than sodium plutonyl triacetate, b) elimination of plutonium was subject to an exponential law; however, there was faster elimination in the case of sodium plutonyl triacetate. A large quantity of plutonium was transported by macrophages from the lungs to the regional lymph nodes. There was slower accumulation of plutonium in the liver at the early stages (20 minutes to 234 hours) after administration of nitrate than after sodium plutonyl triacetate. At the late stages (4-6 months), the plutonium level in the rat liver became the same following administration of nitrate and sodium plutonyl triacetate, constituting 0.9-0.56 and 0.95-0.57%, respectively, of the given dose. The microdistribution of plutonium in the rat liver was primarily diffuse following intratracheal administration of the isotope in the form of nitrate and sodium plutonyl triacetate. The histological changes in the lungs were related to the microdistribution of plutonium and they developed primarily in foci of accumulation of the radioisotope. The severity of the pathological changes and time of their appearance were related to the accumulating ionization dose. The earliest changes consisted of dystrophy and desquamation of bronchial and alveolar epithelium, and perivascular edema. Thereafter, chronic inflammation developed, mainly of a productive nature. Ultimately the pathological process resulted in development of pneumoscelerosis. The sclerotic process usually developed indirectly, on the basis of proliferation of connective tissue cellular elements with formation of fibrous structures. No significant morphological changes in the rat liver following intratracheal administration of plutonium nitrate and sodium plutonyl triacetate in a dosage of 7 uCi/kg were observed. (RAF)

<80>
Ershov, E.B., and D.P. Osanov, 1970, December

Distribution of Plutonium 239 in Intact Skin in Its Surface Contamination. Meditsinskaya Radiologiya, 15(12), 44-46. (Russian)

The penetration of Pu 239 through the epidermis (up to 150 um thick) during superficial contamination was studied using 22 piglets whose morphological skin structure is similar to human skin. The results of the specific activity into the depth of the epidermis at various periods of time of contact with Pu 239 are given in graphic form. It was found that at the beginning the specific activity was very rapidly increased at any fixed depth and after 12 hr of contact the tempo decreased and became balanced, i.e. that the amount of the absorbed and expelled radioactive preparation was equal. (RVJ)

<81>
Foreman, H., Los Alamos Scientific Laboratory, Los Alamos, NM. 1958

Plutonium Binding by Bone. Radiation Research, 9(1), 115.

Previous studies have shown that, when plutonium is shaken with various powdered bone fractions, the fractions from which all of the organic material has been removed have the greatest uptake and the fraction from which all of the calcium has been removed has the least. Other studies strongly indicated that the mode of combination is simple adsorption to the surface of the bone powder. These findings suggested the possibility that plutonium is taken up in the skeleton on the surface of bone mineral, rather than by combination with some organic material as was previously believed. The study is a follow-up of the preliminary findings. Powdered fresh bone was extracted with ethylenediaminetetraacetic acid to remove calcium and after careful washing was shaken with plutonium. As before, very little uptake was noted. Another portion of this calcium-free bone powder was equilibrated with Ca(+2) and then shaken with plutonium. Uptake occurred rapidly and almost to the extent of untreated powdered bone. Autoradiographs of bones of rat fetuses injected with plutonium, i.e., bone

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<81> CONT.
containing both calcified and precalcified areas, showed that plutonium uptake is limited entirely to the calcified portions of the bone. Bones from young rats rendered rachitic by diet were calcified in vitro by standard calcification techniques and then shaken with plutonium. Considerable plutonium was taken up. Similar bone treated in the same fashion, except that Ca(+2) was left out of the calcification solution, showed markedly less plutonium uptake. These findings further indicate that the uptake of plutonium by the skeleton is by combination with the bone mineral. (Auth) (Complete Text)

<82>
Foreman, H., and V. Nigrovic, University of Minnesota, Minneapolis, MN. 1968

Nephrotoxicity of Chelating Agents. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 419-423), 680 p.

The role of manganese(+2) in renal lesion development following the administration of Ca chelates of ethylenediaminetetraacetic acid (EDTA) and diethylenetriaminepentaacetic acid (DTPA) was investigated. The chelates were administered intraperitoneally to rats and the lethality ratio was determined. It was shown that the toxicity of Mn DTPA was measured by lethality was significantly lower than that of the Ca chelate. The effect was less marked in the case of the EDTA chelates. Likewise the toxicity of the Mn chelates using renal tubular findings as the end point was much lower than the Ca chelates. Mn(+2) given along with the Ca DTPA did not influence the toxicity of Ca DTPA. Apparently it is a transient depletion of tubular tissue Mn(+2) and a temporary inhibition of Mn acitivated enzyme that is involved that cannot be replenished or rectified by concurrent adminstration of manganese. (FMM)

<83>
Foreman, H., J. Post, and C. Finnegan, Los Alamos Scientific Laboratory, Los Alamos, NM. 1957

The Effect of Irradiation in the Absorption of Plutonium in the Gastrointestinal Tract. Radiation Research, 7, 267-269.

Male adult 350 g Sprague-Dawley rats were x irradiated with 250, 500, 1000 and 2000 R at a ratio of 55 R/min. Two days after irradiation, each animal was given 5 to 6 x 10(E+6) counts/min of Pu(+4) in 0.5% sodium citrate solution by stomach tube. Both fed and fasted groups of animals were tested. Analyses were done on gastrointestinal tract, lung, skin, liver, skeleton and carcass. The results show that x irradiation, even in high doses, dose not affect the absorption of Pu. An interesting point was the high retention of Pu in the gut of the fasted animals, both the controls and irradiated. This is probably related to the larger amount of chyme in the intestines of the fed animals. The extra intestinal contents probably provide a mechanical scrubbing action which promotes transfer of the Pu into the fecal stream. The relatively high values of Pu absorption as shown by the amount of Pu in the tissues--0.2 to 0.3% in all the animals--as compared to the findings of others of 0.05 to 0.1%, are probably due to use of citrate in the study. (FMM)

Table 1 shows effect of x-irradiation on distribution of Pu administered by mouth.

<84>
Fried, J.F., Argonne National Laboratory, Division of Biological and Medical Research, Argonne, IL. 1961

Influence of Physical State on the Removal of Hydrolyzable Radioelements by Chelation. ANL-6637; Part of Proceedings of the 7th Annual Symposium on Bioassay and Analytical Chemistry held in Argonne, Illinois, October 12-13, 1961, (p. 5-8), 100 p.

Experiments using Th 234, Pu 239, and Ca DTPA were done to determine the efficiency with which an extracellular agent could remove intracellular relatively insoluble deposits of radioactive metals. In one experiment mice were injected intravenously with two forms of Pu (ionic and colloidal) at a level of 3.3 uCi/kg for the ionic and of 2.6 uCi/kg for the colloidal. DTPA therapy, begun 3 days later, consisted of twelve daily IP injections at 500 mg/kg each. It was seen that the ionic Pu was divided almost evenly between liver and bone whereas the amount of colloidal Pu in the liver was over twice that in the bone. In the animals receiving DTPA therapy, ionic Pu was almost completely removed from the liver in 3 days, whereas in those receiving colloidal Pu, the liver still retained almost two-thirds of its initial burden after the entire treatment period was over. In summary, the total reduction of body burden brought about by DTPA therapy was considerably greater in those animals receiving ionic Pu (75% reduction) than in those receiving the colloidal form (40% reduction). (FMM)

<85>
Galkin, G.P., Not given. 1974, June

Distribution of Uranium in the Body After Single and Chronic Entry of Uranium Oxide-Pentoxide. Gigiena i Sanitariya, 6, 37-40. (Russian, English Summary)

The coefficients of uranium retention in the body in case of single introduction by oral and respiratory routes of U308 (0.1 and 25% respectively) were determined in experiments performed on rats. The periods of half-elimination of uranium from the skeleton (T sub eff-300 days), the lungs (10% of initially retained isotope was eliminated at T sub eff 250 to 300 days) and other organs were determined. The periods of half-elimination from the kidneys, liver and spleen did not exceed 16 to 32 days. In a chronic daily inhalation of U308 at a concentration of 1 mg/m (E+3) (0.85 mg/m(E+3)) in the rats' lungs the tissue doses may be about 30 rem/year, that is two times higher than the recommended maximal permissible levels. (Auth)

<86>
Goldthorpe, H.C., and S. Bennett, University of Utah, College of Medicine, Radiobiology Division, Salt Lake City, UT. 1959, March 31

Biochemistry Group. CCO-218; Part of Stover, C.N., Jr. (Ed.), Annual Progress Report, 1959, (p. 72-84), 224 p.

The effects of Pa 226 and Pu 239 (2.5 uCi/kg

<86>

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<86> CONT.
retained dose) on the levels of various serum constituents in dogs are reported and compared to normal values. Normal serum protein values gradually rose to 6.4 g at 4.5 years and then declined gradually. Serum protein in Pu animals decreased after injection, followed by a rise of total proteins at 7 yrs of age. Ra 226 injection was followed by a drop in total protein values. There was then an increase until 3.3 yrs followed by a decrease to 5.8 g at 4.8 yrs. Normal albumin values increased in young animals to 3-4 g at 4.5 yrs, then decreased to 3.0 at 6.5 yr ever going below the globulin values. In animals injected with Pu, albumin decreased quickly, reaching 2.1 g at 4.6 yr, it then leveled off at about 2.3 g at time of sacrifice. Globulin values decreased after injection, but at 2.7 yrs. started to rise reaching 2.7 g at time of sacrifice. Other serum constituents reported on are calcium, inorganic P, alkaline phosphatase, urea nitrogen, chlorides and carbon dioxide. The effect of environmental temperature in blood serum values was also investigated. (FMM)

<87>
Goldthorpe, H.C., L. Hewitt, and S. King, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1962, March 31

An Electrophoretic Study of Serum Protein Fractions in Radium 226 and Plutonium 239 Injected Dogs. COO-225; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 49-58), 136 p.

Dogs were injected with 3.00 uCi Ra 226/kg of 2.77 uCi Pu 239/kg. The serum protein fractions were determined electrophoretically. The results showed that serum albumin values tended to stay fairly normal after Ra 226 injection, while injection of Pu 239 was followed by a lowering of the serum albumin values. The alpha 2 fraction was greatly affected. Plutonium 239 had the greater effect, but the values returned to the normal level after 125 days. Plutonium 239 injection was also followed by an increase of values of the beta 1 fraction. Radium 226 injection appeared to inhibit gamma globulin production at seven days, but from there on up to fifty days there was increased production followed by decreased production lasting up to 125 days. After that time, values followed the normal curve. Plutonium 239 seemed at first to inhibit gamma globulin production. However at 290 days there seemed to be stimulation of gamma globulin production. This may be tied up with beta 2 fraction increases. (Auth) (FMM)

Figure 2 shows the effect of Ra 226 and Pu 239 on albumin and globulin in serum of dogs as compared to normal controls.

<88>
Hamilton, J.G., Argonne National Laboratory, Argonne, IL. 1944, May 2

Technical Progress Report on the Metabolic Studies of Fission Products. MDDC-1061; 2 p. (Declassified June 25, 1947)

A series of tracer experiments with rats have been undertaken with product in all 3 of its valence states in the form of a solution. Production was given at a dose of 15 ug/animal by intramuscular injection, interpulmonary administration and intubation. Results indicate that less than 0.05% was absorbed from the digestive tract in any of the 3 valence states. Following intramuscular injection the plus 4 product was poorly absorbed from the injection site. Of the absorbed fraction 30% was deposited in the skeleton and much smaller amounts in liver and kidneys. Sixteen days after interpulmonary administration 95% was retained by the lungs and 80% of the absorbed dose was deposited in the skeleton. At 16 days following intramuscular injection of plus 3 and plus 6 product the skeleton retained 55% of the absorbed dose. Following intrapulmonary administration 50% of the plus 3 product and 32% of the plus 6 product was retained by the lungs and over 80% of absorbed plus 3 and almost 90% of absorbed plus 6 product was in the skeleton. (RAF)

<89>
Hamilton, J.G., University of California, Berkeley, CA; University of California, San Francisco, CA. 1949, January-June

The Metabolism of the Radioactive Elements Created by Nuclear Fission. The New England Journal of Medicine, 240(22), 863-870.

Significant metabolic characteristics of the fission products and of Np and Pu are listed. It is shown that Np and Pu are not absorbed to any significant degree by the way of the digestive tract. After parenteral administration over half the fission-product group, as well as neptunium and plutonium, are accumulated by the skeleton and eliminated from this organ very slowly. The rates of elimination from the skeleton of neptunium and plutonium are quite slow. The daily excretion of plutonium in the rat falls to 0.01 percent of the amount remaining in the body a year after the intramuscular administration of this radioactive element. Radioautographic studies were made of the distribution of the radioactive isotopes of strontium, zirconium, columbium, cerium, element 61 and plutonium in 5-micron sections of undecalcified rat femurs. It can be seem that most of the Pu is apparently deposited in the periosteum and endosteum, and in the region of the trabecular bone. The direct introduction into the lungs of soluble compounds of the carrier-free fission products, and neptunium and plutonium, demonstrated that the radioelements that were not absorbed from the digestive tract were retained by the lungs to a considerable degree for a prolonged interval. Eight months after exposure to a plutonium oxide aerosol, which is an insoluble compound of the element, 4 percent of the total quantity inhaled still remained in the lungs. Comparable values were observed with plutonyl nitrate, a soluble compound of the element, and with the long-lived fission-product mixture. There was very little absorption from the lungs, and subsequent deposition in the skeleton, after inhalation of the plutonium oxide and fission-product aerosols in an insoluble form. However, nearly 10 percent of the plutonium, when inhaled as an aerosol of the soluble plutonyl nitrate, was absorbed through the lungs in the first 24 hrs and deposited in the skeleton. The property of accumulating in the regions immediately adjacent to the bone marrow gives Pu a significantly greater degree of radiotoxicity than an equivalent amount of Ra. (FMM)

Table 1 shows a summary of the metabolism of the principal members of the long-lived fission

<89> CONT.
products, Np and Pu in the rat after parenteral and oral administration.

<90>
Hamilton, J.G., University of Chicago, Health Division, Chicago, IL. 1945

Technical Progress Report on the Metabolic Studies of Plutonium. CN-3190; Part of Report of Health Activities for Month of July, 1945, (p. 10-17), 17 p. (Declassified December 15, 1955)

A table is presented showing experimental urine and fecal excretion data of a human subject who received 5 ug of Pu 238 intravenously. The average level of daily rates of excretion was about .008%/day of the administered dose and the daily rate of excretion did not show any striking decrease between the 20th and the 37th day. The fecal excretion was about one-fourth that of the urinary excretion. Assays of all samples were done by the lanthanum fluoride and T.T.A. (thio phenyltrifluoroacetone) methods. The T.T.A. method are described in detail. Other studies mentioned are: 1) radioautographic studies on normal, reachitic and Ca dificient rats given Pu, 2) assays of bone from animals subjected to the calcification cycle, and 3) experiments to determine the ability of plants to absorb Pu from day suspensions and from solutions. Results indicate that Pu is most available to plants in the +6 state and least available in the +3 state. (RAF)

<91>
Hamilton, J.G., Not given. 1945, May 9

Technical Progress Report on the Metabolic Studies of Product. CN-2905; Part of Monthly Health Report on Problems Relating to Product for Month of April, 1945, (p. 21-23), 29 p. (Declassified December 22, 1952)

Radioautographic studies from rats that received Pu by intramuscular administration showed that no perceptible differences occurred in the microscopic distribution of Pu in bone between the three principal valence states of Pu. The two principal regions of deposition of Pu in the bone were in the region of the endosteum and the cancellous portion of the bone. The periosteum almost invariably contained many times less Pu than did the region adjoining the endosteum. Results are reported for rats that were exposed to PuO2 aerosols produced by burning neutron irradiated Pu metal which contained fission products. The distribution of Pu and fission products in lungs, liver, kidney, spleen, head, skeleton, urine and feces is given. The uptake by the skeleton of the fission products was considerably greater than that for Pu. The soft tissues had a low content of both Pu and fission products. (FMM)

<92>
Hamilton, J.G., et al, University of California, Radiation Laboratory, Berkeley, CA. 1944, July 14

Technical Progress Report on the Metabolic Studies of Plutonium. CN-1910; Part of Monthly Health Report on Problems Relating to Product for Period Ending June 30, 1944, (p. 4-5). (Declassified February 14, 1956)

Four-day intravenous animal studies with Pu in all 3 valence states showed a similarity of distribution as seen in the intramuscular administration of Pu with the exception of its distribution in the liver. Plutonium in the liver ranged from 28% with Pu plus 6, 36.5% with Pu plus 3 and 71.5% with Pu plus 4. Preliminary 64-day studies of animals given Pu by intramuscular and intrapulmonary administration showed that the retention at the site of injection for Pu plus 3, plus 4 and plus 6 Pu was 42%, 69% and 36%. (RAF)

<93>
Heller, M., Not given. 1948

The Testes. Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 12. McGraw Hill Book Company, Inc., New York, New York, (p. 550-597), 808 p.

The effects on the testis of rabbit, rat, mouse and guinea pig of externally applied beta, gamma and total-body x rays and fast neutrons and of internally administered radioactive isotopes in rabbit, rat and mouse are described. The changes appeared to be quantitatively similar, but there were marked differences in the degree of damage at the LD 50/30 days level. The stem cells were the most radiosensitive elements. Doses as low as 8.8 R per day of gamma rays from an external source had cumulative effects, resulting in complete elimination of spermatogenesis from the guinea pig testis. Following fast neutrons and x-rays at the LD 50/30 days level recovery was usual, rather than permanent sterility. Radium, plutonium, and zirconium 93-niobium 93 proved to be the most destructive to the germinal epithelium; strontium 89, phosprorus 32, barium 140-lanthanum 140, and yttrium 91 caused comparatively milder damage. Not enough animals were treated with the other isotopes to permit definite statements as to their effects. In mice changes in the testis were more severe after a dose of 0.08 uCi/g of Pu intravenously administered than after 0.1 uCi/g given intramuscularly. In rats, a variety of doses (0.125, 0.06, 0.03, 0.015, and 0.008 uCi/g was administered and extensive injury resulted. The observed damage consisted of the nearly complete disappearance of all spermatogenic cells by 120 days after 0.06 uCi/g. Less extensive destruction was noted at 64 days after 0.03 uCi/g and at 150 days after 0.015 uCi/g. Half-life of an agent, type of emission, or pattern of autoradiographic distribution could not be correlated consistently with damage. Except in a few animals in the neutron and radium experiments, the the Sertoli cells did not appear to be significantly altered. The interstitial cells were extremely radioresistant. (Auth (FMM)

<94>
Heller, M., Not given. 1948

Bone. Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 5. McGraw-Hill Book Company, Inc., New York, New York, (p. 70-161), 808 p.

The processes of cessation and resumption of growth of the femur and tibia after treatment with various externally and internally administered radiations were described. There were some similarities between the effects of radiations from external and internal sources. Bone reacted in a similar fashion to the several internally

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administered isotopes, (Sr 89, Ba 140-La 140, P 32, Y 91, Na 24, Ra, Pu, fission-products mixture, Zr 93-Nb 93, Ce-Pr (275 day) and C 14.) Differences observed depended principally on age, species, dose, mode of administration, and interval. In rats injected with radium or plutonium, bone growth was resumed despite the long half-life of the agent. After an initial cessation of growth following injection of strontium 89 into young rats a resumption of growth occurred, which was followed by a second and permanent stunting. This is considered as premature epiphyseal closure. The new bone that formed between the "old" spongiosa and the epiphyseal cartilage was practically free of radioactivity. The deposition of most agents was maximum at the distal end of the femur and proximal end of the tibia, the areas of maximum growth of these bones. In young rats treated with strontium 89, fractures occurred near or in the areas of bone devitalized by the deposition of the isotope. One very early osteogenic sarcoma was observed in the tibia of a Sr 89 treated rat. Several other osteogenic sarcomas were noted after treatment with this agent. Brief references were made to deposition of carbon 14 in bone, to the fact that alizarin and plutonium injected at the same time are deposited in the same places in the bone, and to the distribution in pigeon bones of strontium 89, yttrium 91 and plutonium. (Auth)

<95>
Hobbs, C.H., R.O. McClellan, C.S. Rustgarten, J.A. Mewhinney, J.J. Miglio, O.G. Raabe, and D.O. Slauson, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

Toxicity of Inhaled Alpha-Emitting Radionuclides--An Experimental Approach. LF-49, Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 136-139), 384 p.

A series of interrelated dose-response studies in which beagle dogs and Syrian hamsters were exposed to aerosols of transuranic alpha-emitting radionuclides is described. The characteristics of monodisperse aerosols of Pu 239, Pu 238, Am 241, Cm 244 and Cm 242 oxides are discussed relative to their use in studies to determine the relative importance of such factors as the local dose around the particle, the specific activity of the particle and the size and number of particles inhaled (the hot particle question) on the resulting biological effects. Other factors such as the elemental characteristics and the chemical form of the material and the age of the animal at the time of inhalation which may influence the toxicity of these radionuclides was studied. The purpose of the studies was to determine the basic relationships between the radiation dose pattern and the resulting biological effects. (Auth)

Table 2 shows local and smeared dose estimates for beagle dog lung TLB=1 uCi. Table 3 shows local and average lung dose estimates for Pu 238 PuO2 beagle dog dose-response study (AD=1.5 um).

<96>
Hobbs, C.H., J.A. Mewhinney, D.A. Slauson, R.O. McClellan, and J.J. Miglio, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

Toxicity of Inhaled Plutonium 239 Dioxide in Immature, Young Adult and Aged Syrian Hamsters. 2.. LF-49, Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 150-155), 384 p.

Syrian hamsters have been exposed at either 28 (immature), 84 (young adult) or 340 (aged) days of age to polydisperse aerosols of Pu 239 PuO2 to better define dose-response relationships for this radionuclide in a population with a wide range of ages such as would be the case with a human population following a catestrophic nuclear accident. Animals were exposed to obtain initial lung burdens of 240, 60, 15, 3.8, 0.95, 0.25, and 0.029 nCi for the immature and young adult animals and 240, 60, 15, and 3.8 nCi for the aged animals. Animals are being maintained both for serial sacrifice to determine the radiation dose pattern for lung and other tissues and for lifespan observation to determine dose- response relationships. At the present time, only animals with initial lung burden (ILB) of about 200 nCi or higher exposed at either immature, young adult or aged animals have shown increased mortality as compared to controls. At this time, the young adult or aged animals have shown increased mortality as compared to controls. At this time, the young adult immature and aged animals are 68, 73 and 27 weeks post-inhalation exposure, respectively. The animals that died in the higher ILB groups had radiation pneumonitis and pulmonary fibrosis along with atypical pulmonary epithelial hyperplasia. Histopathological examination is not complete on all animals that have died, but no pulmonary neoplasms have been observed to date. (Auth)

<97>
Hollins, J.G., M.C. Storr, and A. Durakovic, National Research Council, Ottawa, Ontario, Canada. 1974, February

The Effect of Natural Physiological Stresses and Artificial Hormonal Stresses on the Retention of Americium and Plutonium by Rat Bone. CONF-730907 (Part 1); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 743-478), 1475 p.

Americium 241 and Pu 239 were administered by intravenous injection to rats. The injection volume of 0.1 ml obtained 50 nCi of Am 241 or Pu 239. It was found that the retention of americium and plutonium by rat bone varies with age and sex, and during pregnancy and lactation. While the calcium content of bone was substantially reduced by lactation, the retention of americium and plutonium was scarcely affected. When the food consumption of lactating rats was restricted to that of control virgin rats fed ad libitum, the retention of americium by the bone of the lactating mothers was greater than that of the controls. The effect of parenteral administration of parathyroid hormone and a restricted dietary intake of calcium increased the retention of americium at a time when bone calcium was reduced. In contrast, the retention of americium by rat bone during the intense anabolic period of a mother immediately after lactation was less than that of the controls. The retention of americium and plutonium by bone was also reduced after either a series of

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<97> CONT.
intraperitoneal injections of calcium gluconate or parathyroidectomy. (Auth) (FMM) (CTS)

Table 1 shows retention of Am and Pu by rats 7 days after injection.

<98>
Huffman, F.N., and J.C. Norman, Thermo Electron Corporation, Waltham, MA; Cardiovascular Surgical Research Laboratories, Texas Heart Institute, Houston, TX. 1973

Study of the Effects of Additional Endogenous Heat. PH-43-66-982-7; PB-212-952; 240 p.

The feasibility of implantable circulatory support systems depends on the ability of the body to dissipate the reject heat from the power source driving the blood pump. If the energy source is a radioisotope, the body must also tolerate chronic intracorporeal radiation. The objective of the endogenous heat program is to characterize the effects of intracorporeal nuclear radiation and additional thermal load on mammals. The program is a continuation of initial canine studies using electrical heat exchangers and subsequent efforts utilizing heat exchangers energized by 16- and 24-watt Pu 238 (plutonium 238) capsules. More recently, the effects of RES (radiation equivalent source)-24 capsules which simulate the neutron and gamma radiation environment from a 24-watt Pu 238 heat source have been evaluated in mongrel dogs. Within the past reporting period, the two primary foci have been; (1) the implantation of simulated thermal systems (STS) in calves for evaluating the effects of a 50-watt heat load using a functioning left ventricular assist pump as a blood-cooled heat exchanger; and (2) the implantation in primates of RES-50 capsules which model the shape and density of a half-scale power source for driving a blood pump. The long-term survivals in good condition of both Pu 238 and RES implanted dogs and primates, as well as the STS implantations, are encouraging that the anticipated reject heat and dose rate levels from implantable circulatory support systems may be permissible. (Auth)

<99>
Ilyin, L.A., Institute of Biophysics, Moscow, USSR. 1974, February

Regularities in Metabolism of Radioactive Isotopes Upon Incidence on the Skin. CONF-730907(PART 2); Part of Snyder, W.S. (Ed.),, Proceedings, of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 1371-1376), 1475 p.

The report, based on experimental data and calculated-dosimetric estimates presents a discussion on the metabolic regularities of radionuclides of the elements of various groups of the Mendeleev periodic system when their solutions are applied to the skin. Data are analyzed for the levels of accumulation, the mode of intercutaneous distribution and elimination from the skin of pigs of U fission fragments (Cs 137, Sr 89, Ba 140, Y 91, Ce 141,144, Nd 147, Pr 143, Te 132, Mo 94, I 131, as well as Po 210 and transuranium elements Pu 239 and Am 241. Common features in the distribution of these agents in the skin irrespective of their chemical origin have been established. Essential differences in the accumulation levels of radioactive substances in the skin and in the level of percutaneous resorbtion have been found. Uranium, Th, transuranium and transplutonium elements, Te and Po, were classified as radionuclides with a low level of percutaneous resorption, while those with a high level of percutaneous resorption included radionuclides of the alkaline elements, the chromium subgroups, and groups 7 and 8 of the Periodic System. It is shown that transfollicular route is the main way of radionuclide penetration into the body through the skin. (Auth) (FMM)

Table 3 shows kinetics of elimination from the skin of some radioactive substances (H 3, Cs 137, Pu 239, Po 210.)

<100>
Ivannikov, A.T., L.M. Rarbitnaya, and D.D. Smolin, 1964

Effect of N,N,N,N,-Tetracetic 2,2'-Diaminodiethylsulfide on Excretion of Uranyl Nitrate and Course of Uranium Intoxication in Rats. AEC-tr-7590; Part of Moskalev, Yu.I. (Ed.), Distribution, Biological Effects, and Accelerated Excretion of Radioactive Isotopes, (p. 375-380), 405 p.

Male albino rats weighing 140-180 grams were administered subcutaneously 5 mg/kg uranyl nitrate for acute U intoxication. One hour later DDSTA (N,N,N,N,-tetraacetic 2,2'-diaminodiethylsulfide) in the form of the aqueous calcium disodium salt solution in a dosage of 50 umoles/100 grams rat weight was given intraperitoneally for the first 5 days. Uranium content was determined fluorometrically in bones, kidneys and liver. Experimental results were assessed according to survival, change in body weight, and clinical signs of lesions. DDSTA was found be an effective complexing agent for uranyl nitrate; it increased elimination of U from the organism when given at both the early stages after U and at the later stages, when deposition of U has already occurred. The complex compound of U and DDSTA was excreted in the urine. The data pertaining to residual U levels in the rat organism were indicative of a significant decrease in the accumulation of U, particularly in the skeleton, which is the chief reservoir of U. (FAF)

<101>
Jacobson, L.O., University of Chicago, Chicago, IL. 1945, June 15

The Metabolism of Tissues of Rats Treated with Plutonium(+6) Nitrate. CN-2992; Part of Barron, E.S.G., et al, Monthly Health Report on Problems Relating to Product for Month of May, 1945, (p. 37-47), 47 p. (Declassified January 4, 1956)

Rats were injected intravenously with 2 mg/kg Pu(+6) nitrate and sacrificed at different intervals of time from 2 days to 10 days after injection. The metabolism of the following tissues was studied: liver, kidney, spleen, heart, submaxillary gland adrenals, and thymus. The spleen was moderately reduced in size up to 5 days after the injection of Pu. Six days later, however, it went down considerably so that it became only one half or even a third of the normal size. The oxygen consumption of the spleen slices decreased to about half of the normal value by the third day. Pu produced some damage to the liver as shown by a diminished glycolysis, a slight diminution or acetoacetate formation and a slight inhibition in the utilization of pyruvate.

<101>

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<101> CONT.
In the kidney, Pu produced slight damage as shown by a diminished oxidation of butyrate and of glutamate. The respiration of heart slices and the oxidation of acetate were not influenced by the injection of Pu to rats in lethal doses. All the animals showed the characteristic leukopenia produced by Pu injection. (FMM)

<102>
Jacobson, L.C., and E. Simmons, University of Chicago, Chicago, IL. 1945, May

Acute Effects of Plutonium on the Peripheral Blood of Mammals. CN-2992; Part of Monthly Health Report on Problems Relating to Product for Month of May, 1945, (p. 16-18), 45 p.

The effects of intravenously administered Pu (+6) nitrate on the constituents of peripheral blood of the rat have been studied. Doses of 0.0, 0.25, 0.50 and 1.0 ug/gm were given to 4 groups of 9 rats. Mean values of blood constituents sampled from the tail veins at intervals through 167 days are summarized. All three doses reduced the mean level of erythrocytes per mm3 significantly below control levels by 47 days. In rats injected with 0.25 ug/gm a reduction of 30% is apparent, and greater than for the dose of 1.0 ug/gm. At 167 days, recovery had not yet occurred, though values were higher than the 135 day sampling. A 10-20% reduction in mean hemoglobin in all experimental groups was noted at 33 days. This persisted through 167 days. Again, the sharpest reduction was noted in animals receiving 0.25 ug/gm. The mean leucocyte per mm3 fell most precipitously with the highest dose, but was comparable by 7 days and all groups remained low. Heterophils per mm3 were reduced 50% in all groups by 7 days and so. Low with no recovery in 135 days. A similar experiment is in progress using 0.5 ug/gm and 2.0 ug/gm of +6 citrate plutonium. Similar results were obtained with 0.5 ug/gm, but death supervened with the larger dose. (BBM)

<103>
Jee, W.S.S., University of Utah, COllege of Medicine, Medical Center, Radiobiology Division, Salt Lake City, UT. 1971

Bone-Seeking Radionuclides and Bones. Part of Berdjis, C.C. (Ed.), Pathology of Irradiation, Chapter 11. Williams and Wilkins Company, Baltimore, Maryland, (p. 186-212), 710 p.

The chapter is divided into four sections: deposition of radionuclides, radiologically detected changes, histologically detected changes, and induction of malignancy in bone. A summary is given of the deposition of Pu 239, Ra 226, Pa 228, Th 228 and Sr 90 in bones. The calcium-like radionuclides (alkaline earths) are called volume seekers and deposit in sites identical to Ca in bone. In contrast to this pattern, both Pu 239 and Th 228 are deposited on bone surfaces and are called surface-seekers. However radiothorium has a greater variety for reticuloendothelial cells and approximately 25% of the Pu deposites in liver. Some of bone changes occurring in beagles following IV injection of Ra 226, Pu 239, Ra 228 and Th 228 are structural changes in the mandible, destructive changes in the teeth, pathologic fracture with and without healing, distortion of cortex of long bones, distrubance of metaphysical trabeculation, osteolytic rarefaction, rib end demarcation, aspectic necrosis and tumor formation. The radioinduced histologic lesions in bones of beagles injected with Pu 239 are described and a histopathologic hypothesis of alpha irradiation induced bone dysplasia is presented. Some of the factors which influence the effectiveness of a given nuclide in the induction of bone malignancy are summarized. It is pointed out that the bone surface-seeking alpha-emitters are more toxic than the bone volume seekers because more of their energy is absorbed in cells and less is absorbed in mineral. The critical or sensitive tissue in the induction of bone tumors and squamous carcinoma is probably the osteoprogenitor cells and basal layers of the squamous epithelium near bone surface. There is tentative agreement, that the current tumor data on man support the threshold dose-response hypothesis. On the contrary, the mice data still support the linear non-threshold dose-response hypothesis. (FMM)

Table 11.3 shows the incidence of osteosarcomas and carcinoma following deposition of bone seeking radionuclides in man.

<104>
Jee, W.S.S., University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

Plutonium 239 in Bones as Visualized by Photographic and Neutron-Induced Autoradiography. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 171-194), 552 p.

Detailed autoradiographic studies found plutonium 239 to be: (1) a bone surface seeker, (2) non-uniform on bone surfaces, (3) buried by diffusely labeled post-injection bone, (4) removed from bone by osteoclastic activity, (5) concentrated in osteoclasts and macrophages, (6) removed from bone surface by 6 months post-injection in dogs injected with 0.015 uCi of Pu 239/kg, (7) concentrated in macrophages with hemosiderin, and (8) accumulated in macrophages of bone marrow at death. The accumulation of labeled macrophages is an indicator of altered kinetics of both macrophages and bone cells. Labeled macrophages are observed in 2.7, 0.9, 0.3, 0.09 and 0.05 uCi/kg but not in 0.015 uCi Pu 239/kg injected dogs. An improved method for studying the distribution of Pu 239 is described, in which fission fragment tracks and bone image in Lexan plastic films from bones containing Pu 239 were produced when irradiated by thermal neutrons (detailed neutron autoradiography). Preliminary results from counting fission tracks from samples of dog and human bones are discussed. (Auth)

Table 1 gives percentage of Pu 239 associated with sites within lumbar vertebral bodies, as studied by autoradiography. Table 2 gives average skeletal retention and distribution for four 3-level Pu beagles 40 to 560 days after injection. Table 3 gives skeletal retention and distribution for 11 1-level Pu beagles 35 to 769 days afetr injection.

<105>
Jee, W.S.S., G.A. Kenner, M.H. Bartley, N.L. Dockum, M. Sah, H. Mueller, and K. Scheffrahn, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1967, March 31

Preliminary Report: Changes in Vascularity of Cortical Bones Induced by Bone Seeking

<105> CONT.
Radionuclides. COO-119-236; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 97-125), 268 p.

A technique of India ink-gelatin injected vessel hits per unit area of metatarsal shaft was used to determine the alteration in vascularity induced by graded, single intravenously injected dose of Pu 239, Ra 226, Th 228, Ra 228 or Sr 90 in adult beagles. Percent of cross sectional area of bone with vascular channels was 11.4 plus or minus 1.4% in 529 to 3896 day old controls. The reduction in vascularity was dose and time dependent. Significant reduction in vascularity occurred at: 1.1 uCi of radium 226/kg after 1900 days and 2300 rads, 0.096 uCi of plutonium 239/kg after 2200 days and 350 rads, 0.17 uCi of mesothorium 228/kg after 2500 days and 500 rads, 0.032 uCi of radiothorium 228/kg after 1900 days and 250 rads, 100 uCi of strontium 90/kg after 1000 days and 8000 rads. The values for estimates of the accumulated dose necessary for the reduction in vascularity to manifest themselves are as follows: 0.06 uCi of radium 226/kg and 260 rads, 0.016 uCi of plutonium 239/kg and 100 rads, 0.00162 uCi of radiothorium 228/kg and 10 rads, 32 to 100 uCi of strontium 90 and 7000 rads. (Auth)

Figure 5 shows effect of graded doses of Pu 239 on percent vascularity of bones of dogs as a function of accumulated dose.

<106>
Jee, W.S.S., B.J. Stover, D.R. Atherton, R.S. Mical, and P. Tegge, University of Utah, College of Medicine, Salt Lake City, UT. 1962, September 30

The Long-Term Effects of Plutonium 239 in Adult Beagles. COO-226; Part of Dougherty, T.F., Research in Radiobiology, Semiannual Report of Work in Progress on the Chronic Toxicity Program, (p. 95-127), 135 p.

The progress of nine years of work (up to October, 1962) to determine the toxicity of plutonium 239 in the skeleton of adult beagles is summarized. Intravenous injections of 2.8, 0.90, 0.30, and 0.096 uCi/kg plutonium (+4) citrate induced 7/9, 12/12, 12/12, and 7/8 bone cancers. The average accumulated rads to the skeleton varied from 326 plus or minus 70 to 6470 plus or minus 1590 rads. Systematic radiographic and histologic search for bone tumors revealed multiple primary osteosarcomas and the anatomical distribution for each dose level. The anatomical distribution of osteosarcomas differed for each dose level. A squamous cell carcinoma invading the frontal bone was detected in the 0.096 uCi/kg group. The skeleton exhibited radiographically and histologically extensive gross tissue damage in the higher dose levels, while isolated empty lacunae and a slight amount of resorption occurred in the trabeculae of 0.096 uCi/kg dogs. In contrast to the minimal damage of the spongiosa of the 0.096 uCi/kg group. The tibial compact of the same skeleton exhibited a high incidence of canal plugs and loss of osteocytes in osteons. The distribution and redistribution of plutonium are reviewed to emphasize the non-uniformity of the radionuclide in osseous tissue. Detailed radiochemical analyses of bone samples of four beagles injected with 2.8 uCi/kg Pu 239 also revealed a wide variation in the concentration of plutonium in the same bone of several dogs and in various bones of a given dog. The amount of activity in the mandible and shaft of the humerus was fairly low. Correspondingly, the tumors from the shafts of long bones and the mandible were restricted to the higher dose levels. Highest concentration of the vertebral column was in the sacrum and thoracic vertebrae, but most of the tumors arose in the cervical and lumbar regions. The concentrations of plutonium in ribs, scapulae, and pelves were in the same range as the vertebrae, but more pelvic tumors were detected. The addition of lower dose levels, when the animals and space are available to insure a safety factor in the experiment is announced. (Auth)

The incidence of osteogenic sarcomas in beagle dogs injected with Pu 239, the distribution of Pu 239 in the skeleton, the variation of average skeletal dose and numbers and sites of osteogenic sarcomas are given in tabular form.

<107>
Johnson, I.J., R.L. Watters, J.L. Lebel, C.R. Lagerquist, and S.E. Hammond, Los Alamos Scientific Laboratory, Los Alamos, NM, Colorado State University, Fort Collins, CO; Dow Chemical Company, Rocky Flats Division, Boulder, CO. 1972

The Distribution of Plutonium and Americium: Subcutaneous Administration of Plutonium Dioxide and the Effect of Chelation Therapy. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 213-220), 552 p.

Translocation data obtained following subcutaneous implants of PuO_2 in dogs, simulating Pu contaminated wounds which have been experienced in plutonium handling facilities, are presented. Tissue distribution of Pu and Am, with and without chelation therapy, are presented. Results observed include apparent tissue Pu and Am concentration equilibrium within the first two weeks after PuO_2 implants. Chelation therapy did not alter the Pu concentration in the tissues, but significantly reduced the average Am concentration in the skeleton and liver. The importance of rapid removal, where feasible, of imbedded Pu is re-emphasized by these findings. The use of DTPA therapy for the oxide form of Pu in a contaminated wound appears to be of limited value. (Auth)

Table 1 gives percent of implanted Pu in tissuesss. Table 2 gives percent of implanted Am in tissue.

<108>
Kalistratova, V.S., I.S. Katsapov, and V.I. Trifonov, Not given. 1974, February

Biological Effects Observed with Combined Exposure to Radiations. CONF-730907 (Part 1), Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 172-175), 1475 p. (Russian, English Summary)

The combined effects of I 131, Am 241, HTO and of external radiation sources were studied in white rats. The results obtained indicate that combining of radionuclide and whole-body external gamma irradiation in various combinations can be expressed differently, i.e. , either by summation of the effects or by their increase or decrease. (Auth)

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<109>
Kallfelz, F.A., C.L. Comar, P.H. Craig, and A.P. Casarett, Cornell University, New York State Veterinary College, Department of Physical Biology, Ithaca, NY. 1972

Biological Effects of Radiation from Simulated Plutonium 238 Power Sources in Dogs. CONF-720108; COO-3167-28; Part of Proceedings of a Symposium on Research Animals in Medicine held in Washington, D.C., January 28-30, 1972, (14 p.).

The simulated radiation sources used in this experiment consist of a combination of Cf 252 (to provide the neutron component of a 30 watt Pu 238 source) and Sr 90-Y 90 Bremsstrahlung (to provide the additional photon flux needed). The sources, placed into a stainless steel capsule, were implanted into Labrador Retrievers delivering 1, 5, 15, or 70 times the radiation dose expected from a 30 watt Pu 238 power source, and dose rates to various organs were determined. A total of 48 dogs have been implanted to date with a maximum total accumulated dose in a single dog of 37,000 rad at 1 cm from the surface of the implant. Post-mortem examination of some dogs revealed a complete cessation of spermatogenesis and a striking reduction in lymphocyte population of the spleen and mesenteric lymph nodes in the 70 X animals. Similar, though less severe lesions were observed in the 15X dogs. In addition, one 70X dog developed a mast cell sarcoma at the implant site and the 15X and 70X dogs killed after one year showed a reduction in numbers of megakaryocytes and erythropoietic elements in the bone marrows in the vicinity of the implant. No functional changes were seen in 1X or 5X animals. (Auth) (RAF)

<110>
Kalmykova, Z.T., Ministry of Health, Institute of Biophysics, Moscow, USSR. 1968

State of the Red Blood Cells and Hemodynamics in the Case of Inhalation of Ammonium Plutonium Pentacarbonate by Rats. AEC-tr-8013; Part of Radiobiology, (p. 204-208), 232 p.; Radiobiologiya, 8(6), 925-927.

It was shown on 317 rats of the Wistar line (130-160 g body weight) that in the case of a single inhalation of ammonium plutonium pentacarbonate, with the deposition of 0.024-0.032 uCi of plutonium 239 in the lungs, hypoxemia, accompanied by hypervolemia and acceleration of blood flow, periodically arises, in the case of chronic inhalation, during the late periods, 18-20 percent erythrocytes with an increased acid resistance appeared in the blood. (Auth)

<111>
Katz, J., M.H. Weeks, and W.D. Oakley, General Electric Company, Hanford Atomic Products Operation, Richland, WA 1953, April 9

Possible Therapeutic Agents for Radiation Damage. HW-27688, Part of Research and Development Activities Quarterly Progress Report for January-March, 1953, (p. 16).

Glucuronolactone, a compound not previously investigated in connection with plutonium therapy, was shown to affect significantly the distribution of plutonium in the rat, a single intraperitoneal dose given 30 minutes after plutonium administration decreased skeletal deposition by about 25%, decreased soft tissue deposition by about 40%, and increased liver deposition approximately five-fold. (Auth) (Complete Text)

<112>
Kawin, B., University of California, Division of Physiology, Berkeley, CA; University of California, Crocker Radiation Laboratory, Berkeley, CA. 1963

Effects of Zirconium Citrate on Early Femur Uptake and Urinary Excretion of Radioisotopes. Health Physics, 9, 1031-1034.

Effects of single intraperitoneal administration of nonradioactive zirconium citrate on femur uptake and urinary excretion of either simultaneously injected intravenous radioactive cerium (Ce 144), plutonium (Pu 239(+6)) or yttrium (Y 90) were compared in rats during the initial post-injection hour. In the experiment ninety young adult female Long-Evans rats (average wt. 175 g) were intravenously injected with Ce 144, Pu 239 or Y 90 in dosages of 5, 0.5 and 40 uCi/animal, respectively, contained in 0.25 ml of 0.01% sodium citrate, pH 6. Within 30 seconds following injection of radioisotope, forty-five of the animals were intraperitoneally injected with a non-radioactive zirconium citrate solution, in a dose of 40 mg per animal. The results show that zirconium treatment is associated with increased plasma disappearance of Pu 239. Comparisons in control and treated animals indicate that zirconium citrate treatment has no effect to alter rates of femur deposition for the early time interval studied, and that it enhances urinary excretion of Ce 144 and Y 90, with only a very small effect on Pu 239 excretion. (Auth) (RMM)

<113>
Kawin, B., Veterans Administration Hospital, Radioisotope Service, Fort Howard, MD. 1962

Effects of Zirconium on Early Femur Uptake and Urinary Excretion of Radioisotopes. Radiation Research, 16(4), 583

Injection of animals with zirconium citrate solutions is known to alter markedly the distribution and excretion of radioisotopes. Effects of prompt zirconium citrate injections on early plasma disappearance, uptake by femur, and urinary excretion of intravenously administered radioactive cerium (Ce 144) plutonium (Pu 239 (6)) and yttrium (Y 90) were studied in rats. Following treatment the plasma concentrations of the radioisotopes were proportional to the plasma concentrations of zirconium labelled with Zr 95. This effect decreased in the order Ce 144 > Y 90 > Pu 239. Graphical analysis of the data showed that femur uptake could be related by a constant of proportionality expressed in terms of ml plasma "cleared" per unit time. For Ce 144 this amounted to about 0.018 ml/min The corresponding values for the other radioisotopes were 0.0019 ml/min (Pu 239) and 0.0008 ml/min (Y 90). Treatment with zirconium altered the values to 0.008 ml/min (Ce 144), 0.0016 ml/min (Pu 239) and 0.0012 ml/min (Y 90). Analogous values for urinary excretion were generally low, but were increased markedly by the zirconium treatment. The control values amounted to 0.0006 ml/min (Ce 144), 0.0009 ml/min (Pu 239) and 0.0006 ml/min (Y 90). With zirconium treatment these constants amounted to 0.169 ml/min (Ce 144), 0.0019 ml/min (Pu 239) and 0.017 ml/min (Y 90). The use of these proportionalities as measures of

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<113> CONT.
effectiveness of zirconium treatment is discussed. (Auth) (Complete Article)

<114>
Kawin, B., and D.H. Copp, University of California, Medical School, Division of Physiology, Berkeley, CA; University of California, Crocker Radiation Laboratory, Berkeley, CA. 1953

Effect of 2,3-Dimercaptopropanol (BAL) Upon Distribution and Excretion of Plutonium. Proceedings of the Society for Experimental Biology and Medicine, 84, 576-588.

Young adult female rats weighing 200 to 240 g were injected intramuscularly with 15 ug of hexavalent Pu 239 as the chloride. Some animals received 9 injections of 10 mg, 2,3-dimercaptopropanol (BAL) in 0.1 ml peanut oil intramuscularly, at 4 hr intervals following the injection of Pu while others were BAL-pretreated (10 mg BAL 5 hr prior to administration of Pu) and then given BAL after the Pu injection. Urine and feces were collected at 2 days and 8 days following injection of Pu. At the end of 8 days, the rats were sacrificed and liver, kidneys, right femur, right foreleg, left foreleg and carcass were assayed. The results show that intramuscular injection of 2,3-dimercaptopropanol in doses therapeutically effective in arsenic and mercury poisoning had no effect on the distribution and excretion of injected plutonium (hexavalent), whether given prior to or following the administration of the metal. (Auth) (F&M)

Table 1 shows the effects of BAL upon distribution (in liver, kidneys, femur, carcass) and excretion of intramuscularly injected Pu.

<115>
Kenner, G.H., and W.S.S. Jee, University of Utah, College of Medicine, Salt Lake City, UT. 1967, March 31

Effects of Age and Bone-Seeking Radionuclides on the Vascularity of Bones from Adult Beagles. COO-119-236; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 126-143), 268 p.

Celloidin sections of the diaphysis of metatarsal bones injected with India ink-gelatin from adult beagles were studied to determine the effect of aging and internal irradiation on the degree of vascularity and some index of bone remodeling. The experimental dogs were injected with 2.7, 0.9, 0.3, 0.05, or 0.015 uCi of plutonium 239 citrate/kg or 10, 3, or 1 uCi of radium 226 citrate/kg. The degree of vascularity was determined by the observed ratios of the number of haversian canals containing India ink (unobstructed vascular canals) to the total number of haversian canals. Bone remodeling was related to the number of forming osteons. The only change observed with age was a late increase in the number of forming osteons. However, there was a marked decrease in vascularity (decreased percent India ink injected canals and increased plugged canals) in animals given injections of 2.7, 0.9, or 0.3 uCi of Pu 239/kg or injections of 10, 3, or 1 micron Ra 226/kg. The loss in vascularity was more intense and appeared earlier in animals injected with higher doses. Loss in vascularity as measured by injected canals manifested itself at lower accumulated rads than plugged canals. Increased numbers of forming osteons occurred at higher doses of plutonium and radium. (Auth)

<116>
Khodyreva, M.A., Not given. 1965

The Penetration of Plutonium 239 through the Skin. Meditsinskaya Radiologiya, 10, 42-46. (Russian, English Summary)

Experimental studies were undertaken to determine the possibility of plutonium nitrate penetrating the intact skin of rabbits. Plutonium 239 penetration through the intact skin was assessed by the amount of activity in blood and internal organs of the animals. Blood radioactivity was measured by alpha-track photography on thick-layer plates of the A-2-50 type. Plutonium nitrate applied in the form of a solution in a dose of 0.4 and 4 uCi/cm (E+2) of skin surface absorbed through the skin of animals. A relationship was established between the Pu 239 content in the blood and the quantity applied on the skin. In the epicutaneous route of absorption the greatest amount was found in bone tissue. On the 14th day up to 70% of the absorbed quantity was found in the rabbit skeleton. At the end of the observation time about 0.15% remained on the skin. (RAF)

<117>
Konstantinova, V.V., Not given. 1963; 1964

Deoxyribonuclease Acitivity in Rabbit Liver Affected by Plutonium. AEC-tr-5417; Part of Radiobiology, (p. 19-22); Radiobiologiya, 3, 501-503.

Rabbits of both sexes weighing 3.0 to 3.5 kg were intravenously administered a solution of plutonium nitrate in a single dose of 7 uCi/kg. After 1, 3, 7, and 15 days, and after 1, 3, 4, 5 and 6 months, the animals were sacrificed and the activity of DNAase 2 was determined in the liver. The activity of DNAase 2 considerably increased already within a month after priming and reached its maximum value (3.8-fold increase) 4 1/2 months after introduction of the radioelement. (RAF)

<118>
Konstantinova, V.V., and R.E. Libinzon, Not given. 1959, January-February

The Effect of Plutonium on the Content and Renewal of Nucleic Acids in Some Rabbit Tissues. Biochemstiry, 24(1), 897-903.

Rabbits of both sexes aged 6-7 months were injected intravenously with a solution of plutonium nitrate in the amount of 7 uCi/kg (pH 2.0). After 15 days, 1, 3, and 6 months the animals were killed and liver, spleen and bone marrow was analyzed for nucleic acid content. For the determination of rate of renewal of the nucleic acids (by P) the rabbits were injected subcutaneously 4 hrs before sacrifice with a neutral solution of Na2H P 32 O4 in the amount of 50 uCi/kg. When Pu was injected into rabbits in a dose of 7 uCi/kg, was a decrease in weight of the liver after 3 and 6 months and a fall in the number of cells in 1 g of bone marrow at all periods of the investigation. The maximum decrease in content of P-RNA in liver and spleen was observed 3 months after the injection. No change in bone marrow P-RNA

<118>

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<118> CONT.
was observed. The P-DNA content fell markedly in bone marrow and spleen after 3 months, and in liver after 6 months. The amount of DNA and RNA calculated on the weight of the liver fell more sharply than when calculated on the basis of unit weight of organ. The amount of P-DNA in all the organs after 3 and 6 months was 55 and 46%, and the amount of P-RNA was 56 and 36% of the corresponding results for the control animals. The specific activity of RNA increased 1.5-2 times in all the tissues in most of the periods of study. The greatest increase in DNA specific activity was in the liver. The activity of bone marrow depolymerases 6 months after injecting plutonium rose; the activity of DNAase(+2) by 70%, of acid and alkaline RNAase by 96 and 240% respectively. (RAF)

Tables are given on weight of organs, amount of Pu ionization dose, and content of total N and P in rabbit tissues after Pu administration, of content and specific activity of nucleic acid P, and of amount of nucleic acids and intensity of uptake of P 32 in bone marrow cells.

<119>
Kornberg, H.A., Hanford Atomic Products Operation, Biology Section, Richland, WA. 1956, February 16

Biology Research, Annual Report, 1955.
HW-41500; 188 p.

The research activites of the Biology Section were summarized for the year 1955. The reports fall into the following categories: effectiveness of isotopic dilution, studies on radioactive particles, studies in plants and animals including microbial studies, and effects on production facility effluents on rats, fish and plants. Several studies of I 131 in sheep and pigs are reported. Three papers from the report were included in the data base. (HP)

<120>
Kornberg, H.A., and J.J. Davis (Ed.), Hanford Atomic Products Operation, Biology Operation, Richland, WA. 1959, January 5

Hanford Biology Research Annual Report for 1958.
HW-59500; 156 p.

The subjects discussed in this annual report include: uptake and metabolism of strontium and calcium in plants and animals, the retention and elimination of plutonium following different routes of administration, synergism of plutonium and external x-irradiation, translocation of insoluble oxides of Pu 239, Pu 106, Sr 90 SO4 and Ag I 131 in the lung, metabolism of Zn 65 and W 185, intestinal tract irradiation by Y 90, and effects of process effluents on the biota. Three papers were abstracted separately for the data base. (HP)

<121>
Kornberg, H.A., and D.E. Warner (Ed.), Hanford Atomic Products Operation, Richland, WA. 1960, Janaury 15

Hanford Biology Research Annual Report for 1959.
HW-65500; 208 p.

The 38 papers in this 1959 progress report deal with some aspects of internal emitter metabolism and toxicity, and relate some observations on the biological effects of external radiation. Seven papers were abstracted separately for the data base. Areas studied include an investigation of Sr-Ca relationships and their retention in the animal body and in plants; and K, Cs 137 and Pb 86 relationships in plants and soil. Also discussed are aspects of Sr toxicity in miniature swine and the comparative toxicity of Sr 90, Ra 226 and Pu 239 in swine. Other large animal research deals with effectiveness testing of selected radiation protection procedures; the biological effects of I 131 in sheep and swine, and its removal from leaves. The metabolism of P 32 and Zn 65 was investigated in fish, mice, rats, and rams. A method for measuring in vivo P 32 by bremsstrahlung was developed. Radioactive particles studies include the effects of Sr 90 SrO4 inhalation on mice; excretion and translocation of Pu 239 PuO2 after inhalation; distribution and toxicity of inhaled Pu 239 PuO2 and biological effects of Pu and Pu in mice. Papers dealing with the biological effects of radiation discuss the effects of gastrointestinal irradiation on glucose absorption; polyvinylpyrrolidine excretion as an indicator of radiation damage in the intestine; the effects of combined Pu and x-irradiation in rats ; and cytological aspects of irradiated yeasts. A technique was established for measuring the movement of radionuclides across gill membranes. Reports are given on the radioactive contamination of wildlife for 1959; chinook salmon spawning near Hanford; Zn 65 in marine mollusks near the Columbia River mouth; mutation and temperature effects in CHONDROCOCCUS COLUMNARIS; and on the participation in the environmental program of Project Chariot. (RAF)

<122>
Koshurnikova, N.A., and V.K. Leinberg, Not given. 1964

Effects of Aseptic Inflammation on Long-Term Sequelae in Rats Given Plutonium 239.
AEC-tr-7590; Part of Moskalev, Yu.I. (Ed.), Distribution, Biological Effects, and Accelerated Excretion of Radioactive Isotopes, (p. 251-256), 405 p.

Experiments were conducted on 264 Wistar rats of both sexes, with an inital weight of 100-200 g. The rats were divided into four groups. Plutonium nitrate solutions (pH 2) were given once, intraperitoneally in a dosage of 0.63 uCi/kg to the animals in the first group. Turpentine was given to the rats in the 2nd group 15 days after administration of the same dosage of Pu. Only turpentine was given to the 3rd group of rats. The 4th group served as a biological control. 0.1 ml turpentine was given once every 2 weeks for 3 months, subcutaneously in the thigh, to induce aseptic inflammation. The experiments showed that aseptic inflammation combined with small doses of Pu 239 curtailed survival of experimental females. Aseptic inflammation diminished the incidence of bone and hematopoietic tissue tumors in rats of both sexes. Multiple injections of turpentine, administration of small doses of Pu 239, as well as the combination of these two factors, induced some rise in incidence of neoplasms of endocrine glands. (RAF)

Tabular data are given of localization and incidence of tumors and of morbidity in experimental and control groups of animals.

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<123>
Kraevsky, N.A., V.N. Strel'tsova, and Yu.I. Moskalev, Academy of Sciences, Moscow, USSR. 1964

Some Results of Studying the Blastomogenic Effect of Radioactive Isotopes. Acta Unio Internationalis Contra Cancrum, 20, 1151-1154.

Tumors induced in rats by deposited radioactive fission products of uranium were studied in doses from 100 to 1000 times above the maximum permissible level. A 20-30% tumor incidence was observed. Several types of tumors were differentiated according to their mechanism of development as a function of the isotopes distribution in tissues, radiation dose and dose rate. One type of tumor (osteosarcomas, liver and gastrointestinal tumors) resulted from a direct exposure of tissue to ionizing radiation. Another type (tumor of the hypophysis), induced by all the isotopes irrespective of their distribution in tissues, developed by indirect influences as well as by direct radiation exposure. The third group of neoplasms (leucoses, tumors of the mammary glands) occupied an intermediate position. Their incidence increased with dose but was not significantly affected by a change of dose rate. (RAF)

<124>
Krivolutskii, A.L., A.L. Tikhomirova, V.A. Turchaninova, and M. Gerrard (Translator), Institute for Evolutionary Morphology and Ecology of Animals, Moscow, USSR. 1972

Changes in Structure of Animal Populations (Terrestrial and Soil Invertebrates) Due to Soil Contamination with Strontium 90. ORNL-tr-2823; 6 p.; Pedobiologia, 12, 374-380.

A study was carried out on the action of Sr 90 contaminated soil on the structure of animal populations and on the accumulation of Sr 90 by various species of land and soil invertebrates. Birch-pine forest plots were contaminated with 1.8 uCi/m2 Sr 90; observations were made in late spring. Different animal groups reacted differently to soil contamination. The population density of the soil-dwelling microfauna was markedly decreased in Sr-contaminated soil. Saprophytes, rainworms, and diplopods were especially sensitive; no effect was observed in flying insects (Diptera, Staphylinidae, Elateridae) or on Trombididae and Mermithidae. Effects of radiation on overwintered invertebrates were less than on invertebrates in their active and reproductive period. The soil invertebrate population decreased considerably during their multiplication and their next period of maximum abundance in Sr contaminated soil. No pattern could be found of the amount of accumulation of Sr 90 in different species; a wide variation was observed. Snails accumulated relatively more Sr 90 than did rainworms. (RAF)

<125>
Kudasheva, N.P., and N.A. Koshurnikova, 1964

Effects of Additional Pathological Factors on Peripheral Blood of Rats Given Plutonium 239. AEC-tr-7590; Part of Moskalev, Yu.I. (Ed.), Distribution, Biological Effects, and Accelerated Excretion of Radioactive Isotopes, (p. 230-237), 405 p.

Data are given pertaining to the peripheral blood of rats when relatively small doses of Pu were combined with multiple bloodletting and turpentine induced aseptic inflammation. Experiments were conducted on Wistar rats of both sexes weighing 100-120 grams with single intraperitoneal injections of plutonium nitrate (pH 2) in a dosage of 0.63 uCi/kg. Changes in body weight and survival time were studied; blood tests were performed twice a month. Single administration of Pu resulted in a decrease of survival time for males; multiple bloodletting and aseptic inflammation did not alter the response. Repeated bloodlettings extended the survival of male rats. In females, administration of Pu alone as well as a combination of the two other factors, did not alter the mean survival time. Blood letting and aseptic inflammation did not result in any appreciable changes in the number of erythrocytes, hemoglobin or reticulocytes. No significant changes in erythropoiesis was observed. The changes referable to white blood cells, manifested by a gradual decrease in total number of leukocytes and lymphocytes with an increase in neutrophils were attributed to age. Aseptic inflammation and Pu together resulted in progressive depression of leukocyte response. Same increase in thrombocyte number was noted after the 1st and 2nd bloodletting. (RAF)

<126>
LaBauve, R.J., A.L. Brooks, R.O. McClellan, and D.K. Mead, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

Retention, Distribution and Excretion of Plutonium 239 Dioxide Particles Labeled with Ytterbium 169 in the Rhesus Monkey After a Single Acute Inhalation Exposure. LF-49; Part of Boecker, B.B. and Pupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 170-173), 384 p.

Sixteen Rhesus monkeys were exposed to a high fired Pu 239 PuO2 aerosol labeled with Yb 169, and retention, distribution and excretion patterns were determined. After an early rapid clearance phase, which had a half-life of less than one day, the remaining plutonium was retained in the lungs with a half-life that appeared to be greater than 500 days. By 30 days after exposure, 99% of the Pu 239 in the body was in the lungs. At this time, 6 to 10% of the Yb 169 burden was in the carcass and skeleton suggesting that there was dissociation of some Yb 169 from the particles. The remaining Yb 169 activity was in the lungs. There was little Pu 239 in the liver, bone or lymph nodes. The particulate material was cleared rapidly from the gastrointestinal and upper respiratory tracts and appeared in feces over the first four days. The level of Pu 239 in feces returned to background by six days. Urinary excretion of Pu 239 reached a peak by 8 to 10 days and then remained at a constant rate throughout the remainder of the experiment. These data are useful in calculating radiation dose to a variety of organs and relating this dose to the appearance of late effects from inhaled alpha-emitting particles. (Auth)

<127>
Likhtarev, I.A., G.V. Arkhangelskaya, A.I. Dobroskok, I.A. Zvonova, N.F. Korelina, G.P. Krasnoshyekova, V.S. Repin, and A.P. Ushakova, The Institute of Radiation Hygiene, Leningrad, USSR. 1974, February

<127>

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<127> CONT.
Use of a Specialized Analog Computer for the Model of the Metabolism of some Radionuclides. CONF-730907 (Part 2); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 1358-1363), 1475 p.

The application of analog computers in the studies of non-linear models of DTPA action (following Pu injection) and of iodine metabolism, and of an age-related model of strontium and calcium metabolism in man is described. The techniques involved in the solution of the problems are examined and suitable structural schemes to be analyzed on analog computers are suggested. The obtained predictions are in good agreement with some experimental findings, which give every reason to consider the suggested models to be adequate. Thus, the analog computer modelling provides an effective means for the quantitative analysis of the sufficiently complicated non-linear problems of radionuclide transport in the living organism. (Auth) (PMM)

<128>
Lindenbaum, A., D.W. Baxter, and M.W. Rosenthal, Argonne National Laboratory, Division of Biological and Medical Research, Argonne, IL. 1972

Comparison of Blood Clearance and Six-day Tissue Distribution of Monomeric and Polymeric Plutonium 239 in the Beagle. Radiation Research, 51, 540-541.

No comparative metabolic studies of monomeric and polymeric plutonium have been made in the dog, although the distribution, retention, and therapeutic removal of different physical-chemical forms of intravenously administered plutonium in the mouse and rat are fairly well documented. In the present paper we compare the early blood clearance, the urinary and fecal excretion, and the 6-day distribution in liver, spleen, kidneys, lungs, lymph nodes, testes, skeleton, and bone marrow of two widely differing physical-chemical forms of plutonium in the beagle dog. Two-year-old male Argonne-bred beagles were each given a single intravenous injection of 3.5 uCi (about 0.3 uCi/kg) of either monomeric plutonium citrate (about 90% ultrafilterable) or highly polymeric plutonium nitrate (less than 1% ultrafilterable). Results to date indicate a more rapid blood clearance and a high marrow concentration of the polymeric, as compred to the monomeric plutonium. For interspecies comparisons the plutonium preparations used for the dogs were also injected into mice. In both species the content of polymeric plutonium in the marrow of the long bones at 6 days was approximately twice that of the monomeric preparation. The 6-day distribution of monomeric plutonium in the dog tissues will provide baseline values for estimating the combined effect of DTPA and the yeast cell wall polysaccharide glucan. (Auth) (Complete Article)

<129>
Lindenbaum, A., C. Lund, M. Smoler, and M.W. Rosenthal, Argonne National Laboratory, Argonne, IL. 1968

Preparation, Characterization and Distribution in Mouse Tissues of Graded Polymeric and Monomeric Plutonium. Radiochemical and Autoradiographic Studies. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 56-64), 680 p.

Solutions of plutonium(+4) nitrate, adjusted to pH 5.5-6.0 and stabilized with citrate, were fractionated with respect to particle size by passage through Sephadex columns. Three graded solutions of narrow particle size range thus obtained, in which the fraction of plutonium ultrafilterable through cellophane membranes was less than 1%, 30% and 100% respectively, were injected intravenously into mice. At sacrifice, five days later, livers, spleens, femurs and tibial shafts (the latter separated into hard bone and marrow fractions) were removed for plutonium analysis and autoradiography. With increasing ultrafilterability, less plutonium was deposited in liver, spleen and marrow, while more was deposited in bone. Injection of the graded solution containing 30% ultrafilterable plutonium, from which both larger and smaller particles had been removed, resulted in a significantly different organ distribution of plutonium as compared with previously used, ungraded, solutions of the same ultrafilterability. With the graded solutions, the greatest differences in tissue deposition were found between the most polymerized plutonium and the two less polymeric forms. The pattern of deposition in mouse tissues thus appears to depend on aggregation of plutonium-containing particulates to some critical particle size. Filtration of plutonium solutions through calibrated millipore filters indicates that this critical size is below 0.5 u and well above 0.01 u in diameter. Quantitative autoradiography of livers from mice given graded polymeric plutonium showed differences in deposition between parenchymal and littoral cells (60% v. 40%, respectively); the ratio was larger (70% v. 30%) after the graded monomeric solution. Stars in both liver and spleen were seen only after the most polymeric solution. (Auth)

<130>
Lindenbaum, A., M.W. Rosenthal, and D.W. Baxter, Argonne National Laboratory, Division of Biological and Medical Research, Argonne, IL. 1973

Effect of DTPA and Glucan on Decorporation of Monomeric Plutonium in the Beagle Dog. CONF-730431; Part of Proceedings of the 21st Annual Symposium of the Radiation Research Society held in St. Louis, Missouri, April 29-May 3, 1973. Published in Radiation Research, 55(3), 516.

The long biological half-time of monomeric plutonium 239 observed in the liver of the beagle dog following intravenous injection is generally interpreted to be the result of cellular incorporation, analogous to the known intracellular hepatic retention of polymeric plutonium in the mouse. DTPA (diethylenetriaminepentaacetic acid) is known to be ineffective against intracellular deposited Pu because of poor membrane permeability. Yeast glucan, however, has beenly demonstrated in this laboratory to be effective, in mice, in removing hepatic plutonium not mobilized by DTPA. To test the usefulness of these two substances in another species, the dog, treatment with DTPA, either alone or in conjunction with glucan, was begun 6 days after intravenous injection of 0.32 uCi/kg of monomeric plutonium. Beagle dogs (3 per group) received DTPA (100 mg/kg,

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twice weekly) either alone or in addition to glucan (3 injections of 15 mg/kg at 4-week intervals). By 3 months DTPA, either with or without glucan, had removed 50% of the plutonium from the skeleton, 96% from the liver, and between 50% and 90% from the other soft tissues, as compared to untreated controls. Glucan along with DTPA removed no additional plutonium. The high effectiveness of DTPA, with no additional plutonium removed by glucan, suggests that the long retention of monomeric plutonium in the dog liver is probably not due to intracellular incorporation. (Auth)(Complete Article)

<131>
Lindenbaum, A., M.W. Rosenthal, D.W. Baxter, N.E. Egan, G.S. Kalesperis, F.S. Moretti, and J.J. Russell, Argonne National Laboratory, Argonne, IL. 1972, December

Metabolic and Therapeutic Studies of Plutonium and Americium. ANL-7970; Part of Division of Biological and Medical Research Annual Report, 1972, (p. 121-125), 236 p.

The program aims to develop new approaches to the therapy of poisoning by radioactive and nonradioactive metals. Previous work has demonstrated the effectiveness of chelating agents such as DTPA; attention is directed toward other therapeutic approaches aimed at removal of the portion of Pu not readily removed by DTPA. Studies were also carried out on the uptake of normal (calcium) abnormal (of Pu and Sr) metals in cartilage and bone. A progress report is given. Glucan and DTPA were tested in the beagle dog for their ability to reduce Pu deposits. DTPA (100 mg/kg injected IV twice weekly for 12 weeks, starting 6 days after injection of monomeric Pu-239 citrate) removed 50% of the bone burden, 96% of the liver burden, and between 50% and 90% of the burden of all other soft tissue assayed (except marrow). When given as an adjunct to DTPA, glucan (injected in three times at a dose of 15 mg/kg, at 4 wk intervals beginning 6 days after Pu) did not increase or modify the effects of the DTPA. Glucan has been shown to remove a fraction of Pu, presumably intracellular, that is not available for removal by DTPA. To elucidate the mechanism of glucan action, other related substances were tested. Of these, the most effective (pyran copolymer) and least effective (Tilarone) are soluble interferon-inducers. Further work has shown that and the pyran copolymer is also effective in removal of hepatic Pu. The toxicity of the adjuct substances was investigated. In another project employing autoradiography, two new findings were reported: a) in dog liver, 6 days after injection of polymeric Pu, there was a ten-fold increase of the centrilobar concentration of Pu as compared to the peripheral regions, b) species differences in liver function were indicated by a liver concentration of monomeric and polymeric Pu associated with liver parenchymal cells of the dog, compared with those of the mouse. Some results are reported for an experiment on the effects of the physical-chemical state of Pu on lifetime pathological changes in mice. Microscopic studies of bones are being done to correlate bone tumor incidence with skeletal dose and to compare histopathological sequelae in bone as correlated with dose, time and form of Pu administered. (PMM)

<132>
Lindenbaum, A., M.W. Rosenthal, W.M. Westfall, E.S. Moretti, and J. Russell, Argonne National Laboratory, Argonne, IL. 1964, December

Therapy of Poisoning by Radioactive and Nonradioactive Metals. ANL-6971; Part of Biological and Medical Research Division Annual Report, 1964, (p. 212-214), 230 p.

A progress report is given on several experiments conducted. In one experiment, the differential distribution of Pu in the marrow and on the bone surface of the tibial shaft, following administration to mice of 3 Pu solutions of varying colloidal properties, was measured. The colloidal properties of the plutonium solutions were measured by the ultrafiltration technique and by the differential uptake of plutonium in the tissues of the mouse. The plutonium analyses of tissues from mice killed at 6 days showed a different pattern of deposition for each of the three solutions. Injection of a highly colloidal solution (Pu 18% ultrafilterable) was followed by a liver deposition of 80% of the injected dose (I.D.) and a bone deposition of 12.6% I.D. The intermediate colloidal plutonium solution (Pu 30% ultrafilterable) was followed by a deposition of 46% and 24.8% I.D. in liver and bone, respectively, and the monomeric solution (Pu 90% ultrafilterable) by 28% and 42.4% I.D. Another experiment showed that the femur is the most representative bone in terms of uptake of Pu. The femurs represented 7.6% of the total skeletal ash and contained 8.3% of the retained Pu, in the case of the control mice and 7.8% in the case of DTPA-treated mice. Experiments on the long-term effects of DTPA showed that the latent period (time to the death of the first mouse with a bone tumor) increased with the amount of Pu removed by therapy from 153 days in the Pu controls to 236 and 354 days in the two treated groups. It was also found that therapy with the DTPA ester was followed by a removal of a fraction of colloidal Pu unavailable to the Ca chelate of DTPA. Tests with deferrioxamine B-sulfonate (DFOM) were also reported. (PMM)

<133>
Lindenbaum, A., and J. Schubert, Argonne National Laboratory, Division of Biological and Medical Research, Lemont, IL. 1960, August 13

Sustained Action of Injected Chelating Agents. Nature, 187(4737), 575-576.

Measurement of the ultrafilterability of tissue deposits of various radionuclides was made following treatment of animals with chelating agents. The calcium salt of DTPA (335 mgm/kgm body wt. as the acid form) or saline was given intraperitoneally to rats three days after a single intravenous injection of a solution containing 35 ugm Pu 239 in 1 percent sodium citrate at pH 5-6. The rats and their saline controls were killed at intervals of 1, 2, 3 and 7 days after injection. The ultrafilterability of Pu from the bone, liver, and plasma was measured. It was evident that Pu deposited in the tissues had been rendered diffusible by the pentaacetic acid and that the diffusibility remained ten or more times greater than that of the control animals for at least 7 days after a single injection of Pu. The effectiveness of DTPA relative to EDTA in promoting the ultrafilterability of Pu was tested using plasma and heparinized whole blood. The Pu was injected intravenously into rats and 2 ml of blood was

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<133> CONT.
withdrawn 15 min later. Solutions of the chelating agents were added to the whole blood or to plasma to provide final concentrations ranging from 10(E-8) to 10(E-5) M. The superiority of DTPA over EDTA was shown by the sharper rise in the Pu content of the ultrafiltrates at concentrations of chelating agent in the range 10(E-6) M to 10(E-5) M. Similar experiments were made with thorium using Th 234 as a tracer. A similar superiority of DTPA over EDTA in accelerating the excretion of Th from rats was demonstrated. (FMM)

<134>
Iisco, H., and W.E. Kisieleski, Argonne National Laboratory, Division of Biological and Medical Research, Lemont, IL. 1953

The Fate and Pathologic Effects of Plutonium Metal Implanted Into Rabbits and Rats. American Journal of Pathology, 29, 305-321.

Pieces of Pu metal ranging in weight from 0.61 to 1.80 mg were implanted under the skin of 8 male rabbits and 3 female rats. The animals were permitted to live out their life span and were sacrificed only when moribund. The organs (liver, spleen, kidneys, lungs, and testis) were prepared and weighed for chemical analysis and samples were taken for histologic examination. Plutonium determination was also done on urine and fecal samples. The results show that plutonium metal, when implanted subcutaneously into rabbits and rats, disintegrated into many small fragments soon after introduction into the tissues. The pieces were found to be relatively inert locally, and only small amounts of plutonium were absorbed from the implants during an observation period extending to 1048 days. The implantation sites became heavily calcified in all animals. Retention and organ distribution studies gave evidence that rabbits absorbed considerably more plutonium under these conditions than rats. The majority of the animals appeared to suffer no ill effects from the local implants or from the absorbed plutonium. However, one rat died with an osteogenic sarcoma of the spine produced by the deposition of plutonium in the skeletal tissues. The data indicate that both species can harbor considerable quantities of unmetabolized plutonium in the subcutaneous tissues without showing evidence of this in the excreta. (Auth) (FMM)

<135>
Litvinov, N.N., Not given. 1959

Morphological Changes of Bone Tissue in Acute and Subacute Affection with Plutonium. Meditsinskaya Radiologiya, 4(5), 68-72.(Russian, English Summary)

Experiments were conducted on 70 white rats who received intraperitoneally plutonium 239. Considerable changes were seen in the bone tissue upon administration of 0.15, 0.08, 0.04 and 0.02 uCi/g body weight. The changes were most pronounced in the long bones and had a definite sequence of development. In the course of the first days following the administration of plutonium there was an increase of bone resolution with development of cellular-fibrous tissue, containing a large quantity of osteoblasts. After the second week a gradual inhibition of the processes of enchondral ossification ensued, with reconstruction of the bone and a drop of the amount of osteoblasts. At the height of affection (3-5 weeks) total inhibition of the processes of osteogenesis with death of osteogenic tissue was observed. In animals receiving plutonium with specific activity of 0.04 and 0.02 uCi/g body weight, the disturbance of osteogenesis was marked to a lesser degree than in introduction of 0.15 and 0.08 uCi/g in the course of the second month the growth of bones was restored to a certain extent. The formation of a large quantity of immature bone tissue was seen in the metaphyses and diapnyses. At the end of the third month premature cessation of the bone growth took place. The amount of immature bone in various portions of the skeleton increased. (Auth)

<136>
Lloyd, R.D., W.S.S. Jee, D.R. Atherton, G.N. Taylor, and C.W. Mays, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

Americium 241 in Beagles: Biological Effects and Skeletal Distribution. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 141-148), 552 p.

Like Pu 239, injected Am 241 deposits on bone surfaces within the skeleton. No important differences were observed in the gross whole bone distribution of Am 241 compared with Pu 239, in beagles injected with citrate-complexed Am(+3) or Pu(+4). However, autoradiography revealed that the inital distribution of Am 241 upon bone surfaces was more uniform than that of Pu 239. For Pu 239, the deposits on endosteal and trabecular surfaces were about 2 to 4 times greater than on the periosteal surfaces. For Am 241, they were only about 1.5 to 2 times greater than the periosteal deposits. Biological damage from Am 241 in beagles has been observed in all 4 tissues of highest activity concentrations: liver, thyroid, skeleton and kidney. (Auth)

Table 1 gives gross distribution of Am 241 in beagle skeleton compared with that of Pu 239. Table 2 gives relative distribution of Am 241 and Pu 239 in lumbar vertebral bodies and distal femurs of young adult beagles at 3 weeks post-injection.

<137>
Lloyd, R.D., C.W. Mays, W. Fisher, and R. Hintze, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1962, March 31

Total Body Gamma-Ray Counting of Plutonium 239. COO-225; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 76-83), 136 p.

The infrequent gamma rays produced in the radioactive decay of Pu 239 have been used to assay the plutonium content of living dogs each given a single intravenous injection of Pu 239 ranging in activity from 16 uCi to 35 uCi, 200 to 474 days prior to the studies. Unlike the more abundant 17 kev x rays which are almost completely absorbed within a large animal's body, the gamma rays at 100 kev and 380 kev can be employed in the measurement of Pu 239 in the skeleton. Beagles containing 0.1 to 28 uCi Pu 239 were positioned in an arc 33 cm from an 8" x 4" Na(TI) detector inside a steel room with 6" thick walls. For counting periods of 30 minutes, accuracies of 0.6 uCi Pu 239 at 100 kev and 2.1 uCi Pu 239

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<137> CONT.
at 380 keV were obtained. (Auth) (FMM)

<138>
Logan, R., and P. Todd, United Kingdom Atomic Energy Authority, Health and Safety Department, Chapelcross Works, Annon, Dumfriesshire, Scotland. 1968

Whole Body Counting of Plutonium in Rats. International Journal of Applied Radiation and Isotopes, 19, 422-425.

A method for the determination of the Pu-burden of an unanaesthetized animal using plutonium 237 as label for plutonium 239 is described. The plutonium solution was injected intraperitoneally into rats and a diagram of the whole body counting arrangement is given. With the arrangement described background was about 500 counts per minute and a rat burdened with 75 nCi Pu 237 gave 15,000 counts per minute. The counting period was 200 sec in all cases. Preliminary experiments showed that the count rates from different rats with identical body burdens varied by up to 20 per cent. It was therefore not possible to apply the same calibration factor to each rat. In an 18 rat experiment the average difference between the highest and lowest values of the calibration factor for each rat was 5.6% and the worst difference was 10.4%. The main advantage of the whole body counting method is its simplicity and speed. No troublesome excreta collection was involved (except during the first few days) and the body burden of the animal was known virtually without delay. (FMM)

Table 2 compares the Pu 237 found by whole body counting with that recovered at autopsy in liver, skeleton, and other tissues of rats, after injection with 75 nCi of Pu 237.

<139>
Lundgren, D.L., F.F. Hahn, A. Sanchez, and R.O. McClellan, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

Antibody Responses and Pulmonary Lesions After Inhalation of Cerium 144 Dioxide or Plutonium 239 Dioxide and Subsequent Influenza Virus Infection in Mice and Syrian Hamsters. LF-49; Part of Boecker, B.B. and Pupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 211-214), 384 p.

Female mice 8 to 10 weeks of age were exposed by inhalation to Ce 144 CeO2 or Pu 239 PuO2 and Syrian hamsters 12 weeks of age were exposed by inhalation to Ce 144 CeO2. The activity median aerodynamic diameter of the Ce particles ranged from 1.2 to 1.5 um and for the Pu particles, it was 1.0 to 1.6 um. The cumulative absorbed beta doses to the lungs of mice and hamsters and the cumulative alpha radiation dose to the lungs of mice that inhaled Pu was calculated from a 3-component curve fit to the retention of the radionuclide in the lungs. Animals were infected with influenza virus 7 days or 3, 6, or 12 months after inhalation exposure and entered into groups for either serial sacrifice or lifespan observation. Serially sacrificed animals were bled to obtain sera for serological confirmation of influenza virus infection. Syrian hamsters innoculated with influenza virus 3 months after exposure to Ce had a mean initial lung burden of 11 uCi (20,900 rads to the lungs) and those innoculated 6 months had a mean ILB of 12 uCi (28,000 rads to the lungs). In the mice exposed to Pu, there was a mean ILB of 7.4 nCi with 260 rads to the lungs (innoculated 3 months after exposure) and 340 rads (innoculated 6 months after exposure). There was a definite suppression of complement fixing antibody in mice infected with influenza virus 6 months after inhalation exposure to Pu 239 PuO2. Previous observations of severe metaplasia with squamous cell differentiation in mice exposed to Ce 144 CeO2 and subsequently infected with influenza virus was not confirmed by observations of animals examined to date. (PAF)

<140>
Lustgarten, C.S., J.F. Newhinney, C.H. Hobbs, J.L. Mauderly, R.O. McClellan, J.J. Miglio, J.A. Pickrell, and O.G. Raabe, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

Toxicity of Inhaled Plutonium 238 Dioxide in Beagle Dogs. A. Monodisperse 1.5 um Plutonium 238 Dioxide Particles. B. Monodisperse 3.0 um Plutonium 238 Dioxide Particles. 1.. LF-49; Part of Boecker, B.B. and Pupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974 (p. 140-144), 384 p.

Studies on the metabolism, dosimetry and biological effects of inhaled Pu 238 particles have been initiated in beagle dogs. To obtain essential information on the importance of the homogeneity or non-homogeneity of the radiation dose to lung (the hot particle question), dogs have been exposed to monodisperse aerosols (sigma sub g less than 1.2) of Pu 238 PuO2 of either 1.5 um or 3.0 um aerodynamic diameter (AD). By using monodisperse particles of these two sizes, the average dose to lung is held constant for a given initial lung burden (ILB) but the local alpha dose around the two sizes of particles varies by a factor of about 10. To date, 48 dogs have been exposed to each of the two particle sizes of Pu 238 PuO2 (total of 96 dogs) resulting in graded ILBs which range from 0.008 to 2.2 uCi/Kg of body weight. Sixteen dogs exposed to a diluent aerosol are serving as controls. Of the total activity inhaled, the dogs exposed to 1.5 um AD particles deposited 53% in total body and 43% in the pulmonary region while corresponding deposition values in the dogs exposed to 3.0 um AD aerosols were 73% and 45%. All the dogs are surviving with no detectable abnormalities at from 10 to 293 days post-inhalation exposure. It is anticipated that an additional 48 dogs (24 for each particle size) and 8 controls will be added to these dose response studies over the next few months. In addition, a serial sacrifice study will be initiated to determine the radiation dose pattern resulting from inhalation of these monodisperse sizes of Pu 238 PuO2. (Auth)

<141>
Mahlum, D.D., J.L. Palotay, and W.J. Clarke, General Electric Company, Hanford Laboratories, Biology Laboratory, Richland, WA. 1965, May 29

Effect of Internal Emitters on Liver Tumors Induced by Dimethylaminoazobenzene. Nature, 206(4987), 945-946.

Female rats were injected intravenously with

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<141> CONT.
a beta-emitter Ce 144-Pr 144 (2 or 20 uCi/rat), or an alpha-emitter, Pu 238 (2 uCi/rat). The rats were fed a diet high in riboflavin and protein to which 0.06% DMAB was added. Tumor development was evaluated at various intervals. After 44 weeks the animals were sacrificed and a histopathological examination of tissues was carried out. A decreased incidence of tumors was found in the internally irradiated animals, especially those receiving the higher dose of Ce 144-Pr 144 in addition to DMAB. The effect of radioisotope treatment was a decrease rather than an increase in tumor incidence. Histopathological changes found in the livers of rats fed DMAB were those of degeneration, hyperplasia, and neoplasia involving the parenchyma, bile ducts, and supporting connective tissue, either singly or in combination. Animals that received only the radionuclides showed none of the foregoing pathological changes. The authors postulate that cells in the early stages of carcinogenic development are susceptible to small quantities of radiation and are destroyed before extensive multiplication can occur. (RAF)

<142>
Markley, J.F., Argonne National Laboratory, Division of Biological and Medical Research, Argonne, IL. 1963

Removal of Polymeric Plutonium from Mice by Combined Therapy with the Calcium Chelate and Penta-Ethyl Ester of DTPA. International Journal of Radiation Biology, 7(4), 405-407.

CF No. 1 female mice, 70 days old, weighing 21-23 g were each given 0.092 uCi Pu 239 in 0.2 ml intravenously. Various groups were given a series of intraperitoneal injections once a day for 11 days of 0.2 ml of either saline (controls), DTPA ester at 75 mg/kg, Ca DTPA at 350 mg/kg or Ca DTPA at 300 mg/kg immediately followed at DTPA ester at 75 mg/kg. Livers, spleen and femurs were analyzed for Pu. It was seen that deposition was high in liver and spleen and low in the skeleton. Treatment with either Ca DTPA or DTPA ester alone significantly lowered the Pu content of the liver by about the same amount in each case (28% reduction). Treatment with Ca DTPA and DTPA ester combined gave a total reduction (50%) which is directly additive of the effect of each. The Pu content of the spleen was raised by treatment with either agent singly, indicating that some of the Pu removed from the liver was redeposited in the spleen. However, when combined treatment was given, this increase was prevented; moreover the level in the spleen was lowered significantly below that of the controls (60% reduction). The Pu content of bone was reduced by treatment with Ca DTPA alone, but was unaffected by the DTPA ester, and the effect of the combined treatment on bone was the same as that of the Ca DTPA alone. (FMM)

A table shows the effect of treatment with DTPA ester and Ca DTPA singly and in combination on the distribution of polymeric Pu in mice.

<143>
Matveev, V.I., Institute of Biophysics, Moscow, USSR. 1971, April-June

A Technique for Dosed Administration of Radioactive Aerosols to Dogs. Hygiene and Sanitation, 36, 254-258.

A method is described for a one-time dosed direct intratracheal administration of aerosols to dogs which prevents substances from entering the gastrointestinal tract by licking aerosols off their body surfaces or from passing from the nasopharynx into the gastrointestinal tract. Dogs inhaled aerosols generated from solutions of plutonium nitrates and plutonium citrates with activities ranging from 2 to 23.8 uCi/ml. The migrational activity from the lungs to the internal organs was determined by radiometric analysis of lungs, liver, blood and femur. Retention of isotope was determined to be about 24% of the inhaled isotope. (RAF)

A table is given with calculations of the amount of isotope retained in the dog's body after inhalation of Pu 239 aerosols.

<144>
Mays, C.W., B.J. Stover, B.W. Glad, and D.R. Atherton, University of Utah, College of Medicine, Radiobiology Division, Salt Lake City, UT. 1959, March 31

Skeletal Dosimetry in Utah Beagles. COO-218; Part of Stover, C.N., Jr. (Ed.), Annual Progress Report, 1959, (p. 121-145), 224 p.

Values for the skeletal retention of Pu radiothorium and strontium in beagles were obtained. Equations were developed for the average skeletal radiation exposure at any time after injection in units of rads/day, rads, and rad-days. Values were plotted for a 1-level dog in each toxicity group. (Auth) (FMM)

<145>
McClellan, R.O., B.B. Boecker, F.F. Hahn, C.H. Hobbs, R.K. Jones, and M.B. Snipes, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, February

Comparative Toxicity of Inhaled Beta-Emitting Radionuclides in Beagle Dogs. CONF-730907 (Part 1); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 208-213), 1475 p.

Four lifespan studies are being conducted in which Beagle dogs have been exposed via inhalation to aerosols of fused clay particles containing Y 90, Y 91, Ce 144 or Sr 90 resulting in graded initial lung burdens of radioactivity. With all four aerosols, the labeled particles are tenaciously retained in the lung with effective retention half-times of 2.6, 53, 178 and 400 days, respectively. With the Y 90, Ce 144 and Sr 90 in fused clay, the physical half-life is sufficiently long to allow translocation of small quantities of radioactivity, presumably in particulate form, to tracheobronchial lymph nodes and movement of solubilized Y 91 and Ce 144 to liver and skeleton and Sr 90 to skeleton. With the highest initial lung burdens, deaths related to radiation pneumonitis and pulmonary fibrosis were observed in all four studies within 400 days post inhalation exposure. The radiation dose required to produce early deaths was lowest for Y 90 and highest for Ce 144 and Sr 90 being related to the lung retention half-times (and rate of decrease of radiation dose rate). Later deaths (greater than 640 days) related to primary pulmonary hemangiosarcomas have been observed in dogs that inhaled 144 Ce or Sr 90 in fused clay with cumulative lung doses greater than

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20,000 rads. The current status of the studies (to 1800 days post-inhalation exposure) is discussed and compared with similar studies conducted with Pu 239 PuO2 at Battelle-Northwest. Of special interest is the development of primary pulmonary hemangiosarcomas (endothelial tumors) with chronic alpha irradiation from plutonium. (Auth)

<146>
McClellan, P.O., H.W. Casey, J.W. Cable, and L.K. Bustad, Hanford Atomic Products Operation, Richland, WA. 1962, January 15

Transfer of Heavy Radionuclides to Milk. HW-72500; Part of Kornberg, H.A. and Swezea, E.G. (Eds.), Hanford Biology Research Annual Report for 1961, (p. 44-49), 180 p.

Mature puregred Suffolk sheep in their second to fourth month of lacation were injected intravenously with Ce 144, Pr 144, Np 237, Pu 239, and Am 241 in the following amounts and forms: Ce 144-Pr 144 at a dose of 1000 uCi in the form of the chloride, Np 237 at a dose of 150 uCi, as the nitrate, Pu 239 at a dose of 150 uCi, as the nitrate and Am 241 at a dose of 150 uCi in the form of chloride. Milk and blood samples for radioanalysis were collected at frequent intervals for up to 10 days post-injection and the plasma and milk concentration of the nuclides were expressed as per cent of injected dose and plotted against time post-injection. Both Ce 144-Pr 144 and Am 241 disappeared rapidly from the plasma and were concentrated in milk, whereas Np 237 and Pu 239 both disappeared slowly from plasma and the milk concentrations were always less than those found in plasma. The average milk-to-plasma ratios were: Ce 144-Pr 144, 3.4; Np 237, 0.05; Pu 239, 0.025; and Am 241, 2.3. From the data available, it would not appear that any of these heavy radionuclides would represent a significant hazard to man via ingestion of milk from animals grazing on contaminated forage. (FMM)

<147>
McClellan, P.O., G.S. Vogt, J.P. McKenney, M.E. Kerr, and L.P. Bustad, Hanford Atomic Products Operation, Richland, WA. 1962, January 15

Comparative Toxicity of Strontium 90, Radium 226, and Plutonium 239. HW-72500; Part of Kornberg, H.A. and Swezea, E.G. (Eds.), Hanford Biology Research Annual Report for 1961, (p. 36-40), 180 p.

Twenty-one female miniature swine were injected intravenously with Sr 90, Ra 226, or Pu 239 in doses of 64 uCi Sr 90/kg, 6.4 uCi Ra 226/kg, or 1.3 uCi/Pu 239/kg. Severe reduction in leukocyte numbers were seen during the first three months after radionuclide injection. Neutrophils showed a greater depression than the cell types. The most severe change was evident in the groups administered Pu 239. Nine male animals injected 18 months previously and their controls were sacrificed to provide specimens for study of early histopathological and histochemical changes. (Auth) (FMM)

<148>
Mewhinney, J.A., J.J. Miglio, C.H. Hobbs, and P.O. McClellan, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albequerque, NM. 1974, December

Short-Term Metabolism of Three Sizes of Monodisperse Plutonium 238 PuO2 Aerosols in Beagle Dogs. LF-49; Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974 (p. 37-39), 384 p.

Inhalation exposures of 30 beagle dogs were conducted using monodisperse and polydisperse aerosols of Pu 238 PuO2 to measure the initial pulmonary deposition and short term translocation of Pu 238 to other tissue. Three sizes of monodisperse aerosols (0.7, 1.5, 3.0 um AD) were compared with a single polydisperse size (1.5 um AMAD) in this study. Animals were sacrificed at 0, 8 and 32 days after inhalation exposure and tissues analyzed for Pu 238 content radiochemically. Initial pulmonary deposition decreased as monodisperse particle size increased and the polydisperse aerosol closely resembled the smaller monodisperse size in initial deposition. Upper respiratory clearance was nearly complete at 8 days after inhalation. Minimal translocation of Pu 238 to tissues was found at 8 and 32 days post-inhalation exposure. Transport of Pu 238 PuO2 particles to tracheobronchial lymph nodes appeared to be particle size dependent at 32 days after inhalation. (Auth)

<149>
Moskalev, Yu.I. (Ed.), 1971

Remote Aftereffects of Radiation Damage. AEC-tr-7387; 574 p.

The collection of 68 articles presents the most recent data on tumorous and nontumorous forms of remote aftereffects arising with damage by external sources of ionizing radiation and incorporated radioactive isotopes. Two articles have been abstracted spearately for the data base. Materials include new data on the spontaneous frequency of tumors in animals, on remote aftereffects following exposure to high-energy protons, mixed gamma-neutron and external beta irradiation, and also plutonium 239, polonium 210, americium 241, protactinium 233, tritium oxide and uranium, the effect of radiation on offspring, on the prevention of remote aftereffects, and also information on the relationship between the primary mechanisms of the action of radiation and remote aftereffects. Extensive data have been used in convincingly demonstrating the exceptionally high blastomogenic activity of the rare earth and transuranium elements (Ce 144, Pa 233, Pu 239, Am 241). Pu 239 has an exceptionally high blastomogenic activity. In the case of damage by this radioactive element tumors of the bones and lungs and also sclerotic processes in the pulmonary tissue and subcutaneous cellular tissue arise with the accumulation of very insignificant doses. Facts are being accumulated indicating a dependence of the osteosarcomogenic effect of Pu 239 on the path and rhythm of administration. It was found that the osteosarcomogenic activity of Pu 239 in the case of inhalation and chronic peroral administration is greater than in the case of a single intravenous administration. The lesser (in comparison with Pu 239) biological and osteosarcomogenic effectiveness of another transuranium element, Am 241, was somewhat unexpected. As revealed by the latest data, this is attributable to peculiarities in the microgeometry of the distribution of the considered emitters in the bone tissue. In contrast to Pu 239, the relatively great

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quantities of Am 241 in the bone tissue are bound with mineral structures, whereas protein structures (sialoproteins, transferrin) hold considerably greater quantities of Pu 239. For the first time data are presented on the blastomogenic effects of Sr 90 on the glial elements of the central nervous system and on the biochemical changes in the lungs after inhaling Pu 239 and Am 241. One hundred five tables, 208 figures and bibliography of 1,028 items are included. (FMM)

<150>
Moskalev, Yu.I., and J.F.S. Bradley (Translator), 1958

Regularities in the Distribution and Toxicity of Radioelements. Biofizika, 3(5), 725-731.

Some regularities in the distributions and biological effects of radioisotopes are discussed. The elements in any one group of the periodic system behave very similarly. The types of distribution distinguished are the skeletal, the liver, the uniform and the kidney. Complexing agents, carriers and pH alter the distribution types found with elements having hydrolyzable compounds; they produce no effects with elements giving mostly soluble compounds. Toxicities should not be evaluated in terms of activity alone, since the radiation dose is the primary parameter, and not the decay rate. The effectiveness of any emitter depends on its physical parameters (energy, emission type, half-life) and on its physiological behavior (distribution type, rate of elimination, degree of absorption from depots). The data indicate that some elements (Sr, Ba, Ra, Y, Zr, Pu) are osteophilic, while others (La, Ce, Pm, Pr, Am, Cm) are selectively deposited in the liver; some accumulate largely in muscle (K, Cs, Rb), whereas others tend to prefer the reticuloendothelial system (Nb, Ru, Te, Pc). (Auth) (FMM)

Table 2 shows time doses produced in organs (skeleton, liver, kidney, spleen, bone marrow) after injecting LD 50/30 amounts of emitters (including Cs 137, Sr 90, Y 91, Pm 147, Pu 239, U 233).

<151>
Moskalev, Yu.I., L.A. Buldakov, and V.N. Strel'tsova, 1961, December 8

Dependence of the Biological Action of Plutonium Upon the Rhythm of Its Entry Into the Organism. JPRS-11322; Part of Radiobiology, (p. 297-315), 453 p.; Radiobiologiya, 1(2), 250-256.

Male and female rats weighing 170-200 g were administered intraperitoneally plutonium citrate solutions (pH 6) in a single or fractional doses of 0.00125, 0.005, 0.02 or 0.08 uCi/g of rat weight. The effects on duration of life, body weight, peripheral blood and occurrence of tumors was investigated. The lifespan of rats given Pu depended not only on the dose but also on the rhythm of the isotope introduction. At doses of 0.00125 uCi/g the life span did change and was not dependent on the rhythm of intake. In doses of 0.005-0.08 uCi/g, fractional administration prolonged the life of the animals. LD 50 values increased with fractional Pu administration. Changes in the body weight and hematological values were first less pronounced than at later periods when isotope administration was discontinued. At a dose of 0.00125-0.02 uCi/g tumors of body tissues developed both in single and fractionated Pu introduction. (RAF)

<152>
Moskalev, Yu.I., E.J. Rudnitskaya, L.A. Buldakov, A.P. Nifatov, and L.G. Filippova, Not given. 1974, February

Remote Aftereffects Associated with Damage by Transuranium Elements. CONF-730907 (Part 1); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 167-171), 1475 p. (Russian, English Summary)

In experiments on rats and dogs the late effects of malignant and neomalignant development after the intake of various compounds of Pu 239, Am 241 and Np 237 were studied. It has been shown that dogs and rats after the intake of transuranium elements develop osteosarcomas, leucosis, tumors of lungs, liver, kidneys and other organs, sclerotic processes (contracted liver, nephrosclerosis, pneumosclerosis) at the sites of deposition or transition of the isotope and septical processes of various localization. After the intake of Pu 239 the minimum osteosarcomogenic dose is within 5 rad and after Am 241-17 rad. The maximum frequency of osteosarcoma developement after the intake of Am 241 is 33% in rats and 100% in dogs. With the decrease of dose accumulated in the bone tissue the relative osteosarcomogenic efficiency is increased in dogs as compared to rats from 3 to 30 times. When the doses are close to minimum effective ones the osteosarcomogenic activity of Pu 239 is five-fold that of Am 241. The development of leucosis after the intake of transuranium elements occurs more often and at earlier periods relative to control animals. The maximum yield of kidney tumors (2-4,5%) is observed with Am 241 when the doses used are within 35-200 rad. After the inhalation of scluble compounds of Am 241 the frequency of pneumosclerosis and lung tumor development is lower as compared to Pu 239. The routes of Am 241 and Pu 239 intake into the body do not affect the values of carcinogenic doses for the particular tissue. The minimum osteosarcomogenic and leucomogenic dose for nitrate of Np 237 after intravenous injection is below 0.1 Ci/kg. (Auth)

<153>
Moskalev, Yu.I., V.N. Strel'tsova, and V.K. Lemberg, Not given. 1969

Remote Sequelae of Radiation Damage. AEC-tr-7195; Part of Moskalev, Yu.I. (Ed.), Radioactive Isotopes and the Body, (p. 439-458), 458 p.

The remote effects of radiation damage are grouped into tumorous and nontumorous forms of injury. Both forms of injury are experimentally documented; included are pertinent literature findings. The nontumorous forms are pathological processes such as nephrosclerosis, cirrhosis of the liver, pneumosclerosis, different versions of vascular pathology and endocrine disturbances. These pathological processes are determined by the region and form of irradiation, the dose, the biological properties of the irradiated substrate, etc. Experiments on white rats, after a single total irradiation with protons and neutrons or with a single intraperitoneal injection of Sr 90 or Po 210, showed cirhosis of the liver in approximately 8-20% of the exposed animals. Alpha-emitters exhibited a greater

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cirrhotic effect than beta-emitters. Nephroscherosis arose in 6-18% of rats irradiated once by protons or neutrons. Irradiation by alpha particles of incorporated Po 210 caused a rise in nephrosclerosis in about 40% of rats. The frequency of the disease reached a maximum (81% in males, 100% in females) for a dose of 0.0048 uCi/g. Pneumosclerosis developed preferentially in cases of inhalation or intratracheal intake of poorly resorbing radionuclides. Experiments with intratracheal Pu 239 PuNO34 administration to rats in a quantity of 7 uCi/g showed that the development of pneumosclerosis occurred in several stages characterized by a clear correlation between the dose and the reaction of the parenchyma. Endocrine disturbances were observed in 50% of irradiated animals. Experimental data on the tumorous forms of remote sequelae were obtained with a single irradiation of white rats by protons and neutrons, and by alpha and beta-emitters. Plutonium 239 was injected intraperitoneally into rats and rabbits in doses of 0.00001 to 0.0006 uCi/g and Po 210 was injected intraperitoneally into rats at doses of 0.0003 to 0.02 uCi/g. The beta-emitters were Sr 90, Sr 89, Ba 140, Y 90, Y 91, Ca 45, P 32, Ce 144, Pm 147, La 140, Nb 95, Cs 137 and Ru 146. Malignant and benign new growths of different tissues (osteosarcomas, leukoses, tumors of the gastrointestinal tract, liver, kidneys, lungs, sexual organs, internal secretion glands, etc.) developed on the average in 37% of the rats and 86% of rabbits tested in the chronic phase of radiation injury caused by alpha or beta emitters. Neutrons and protons exhibited the greatest blastomogenous effect causing the appearance of tumors in 44-45% of males and 77-83% of females. Multicentric growth of tumors was observed both under external neutron and proton irradiation and in cases of radionuclide incorporation. Radiations with a high ionization density exhibited a higher carcinogenic activity than radiations with lower ionization density. The possibility of suppression or stimulation of some tumor forms is presented with a discussion and with some experimental data on tissue mitotic activity. (PAT)

<154>
Moskalev, Yu.I., and V.M. Streltsova, Not given. 1965

Radiation Cancerogenesis and the Problem of Restoration. Meditsinskaya Radiologiya, 10, 40-47. (Russian)

The frequency of occurrence of osteosarcomas and leukemia in rats was investigated after successive injections of Sr 90, Ce 144 and Pu 239 over various time periods varying from a daily injection to an injection each 4 months. Out of a total of 526 rats, osteosarcomas were found in 99 rats, and leukemia was diagnosed in 32 cases. The frequency of occurrence of leukemia did not change with increased time of administration of a given amount of activity. On the other hand the frequency of occurrence of osteosarcomas decreased with increasing time of administration. Thus, on introducing a total of 102 uCi of Ce 144 into a rat in five shots once a week, once each 2 weeks, and once each four weeks, the percentages of osteosarcomas were 60, 40 and 31% respectively. With the shots the percentages were 45%, 33% and 0% respectively. Similar results were obtained with Sr 90. With the alpha emitter Pu 239, fractionation of the dose resulted in an increase in the frequency of occurrence of osteosarcomas. Thus, a single injection of 1.25 x 10(5-3) uCi of Pu 239/g gave a 3% frequency of osteosarcomas. The same amount of Pu 239 injected daily over a period of 50 and 100 days gave osteosarcoma frequencies of 14.2 and 11.1% respectively. With weekly intervals between shots this frequency increased to 21.4%. The more differentiated tumor forms were found in those cases where the dose to the bone tissue was low. (TIT)

<155>
Moskalev, Yu.I., V.F. Zhuravlev, A.G. Istomina, I.K. Petrovich, and D.A. Kazbekova, Institute of Biophysics, Moscow, USSR. 1971

Relative Biological Effectiveness of Tritium. CONF-710809; Part of Moghissi, A.A. and Carter, M.W. (Eds.), Proceedings of a Symposium on Tritium held in Las Vegas, Nevada, August 30-September 2, 1971. Messenger Graphics, Publishers, Las Vegas, Nevada, (p. 240-244), 807 p.

The effects of beta radiation from tritium were compared with the gamma radiation from Cs 137 in order to determine the RBE. Experiments were performed using 587 rats. Tritiated water was given to animals in quantities of 3.0, 2.0, 1.0, 0.6, 0.3, 0.15 mCi/g body weight. Other rats were continuously exposed gamma radiation of Cs 137 in a special installation at the same incident dose rate as was calculated for the tritium. The RBE of tritium was measured in terms of the following indices: survival rate, peripheral blood response, and thymic and splenic weight responses. The dose causing death of one-half of the rats within the first four days was 1.86 and 3.72 kilorads for tritium and gamma radiation, respectively. Hence, the RBE of tritium oxide is equal to two. On the basis of mortality rates with various doses of tritium oxide and external gamma radiation, doses were calculated which caused death of 50% of rats by days 12 and 30. In the case of gamma radiation of Cs 137, the LD 50/12 was 1820 plus or minus 134 rads, and in the case of tritium 1350 plus or minus 30 rads (P=0.05). The LD 50/30 was equal to 1200 plus or minus 43 and 895 plus or minus 53 rads, respectively. These results show that the RBE of tritium is equal to 1.35 and 1.34. Thus, the RBE of tritium oxide lies between 1.34 and 2.0 using the survival criterion. When used in acutely effective doses (3.0 to 0.6 mCi/g body weight or 3000 to 690 rads) tritium and gamma radiation led to strongly marked leukopenia in the rats. The degree of leukopenia following exposure to equal doses was greater with tritium than with gamma radiation. The dose causing a 50% decrease in leucocyte count was 224 rads for tritium and 426 rads for gamma radiation. The dose causing in twofold decrease in lymphocyte count, one day after exposure, was 270 rads for tritium and 390 for gamma radiation. The RBE of tritium is thus 1.45. Analysis of the results has shown that, judging from the responses of peripheral blood and thymic and splenic weights, the RBE of tritium oxide lies between 1.45 and 1.93. Thus, in the case of acutely effective doses, tritium beta radiation is biologically more effective than the gamma radiation of Cs 137. The relatively greater biological effectiveness of tritium appears to be due to the fact that it develops 10 to 30 times as great ionization density per unit tissue volume as x or gamma radiation. (FMM)

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<156>
Muggenburg, B.A., J.A. Mewhinney, J.J. Miglio, D.O. Slauson, and R.O. McClellan, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

Bronchopulmonary Lavage and DTPA Treatment for the Removal of Inhaled Plutonium 239 of Varied Solubility in Beagle Dogs. 2.. LF-49; Part of McClellan, R.O. and Rupprecht, F.C. (Eds.), Inhalation Toxicology Research Institute Annual Report, October 1, 1973 through September 30, 1974, (p. 269-273), 342 p.

The efficacy of bronchopulmonary lavage and chelation therapy was determined for removing Pu 239 from beagle dogs after inhalation of Pu 239 aerosols of differing in vivo solubility. The four aerosols used were nebulized from a solution of Pu 239 PuCl4 and heat treated at temperatures of 325, 600, 900 and 1150 degrees C, respectively. Six dogs were exposed to each of the four aerosols and 3 dogs in each group were treated subsequently by lavage and intravenous diethylenetriaminepentaacetic acid (DTPA); three dogs served as untreated controls. Tissue accumulation of Pu 239 in the untreated control dogs at sacrifice 56 days post-exposure, expressed as a percentage of the initial lung burden (ILB), was 6% in liver and 9% in skeleton for the 325 degrees C aerosol group, 1% in liver and 2% in the skeleton for the 600 degrees C group, and less than 0.6% in these tissues for the 900 degrees and 1150 degrees C aerosol groups. Tissue accumulation was 1.0% or less of the ILB for all organs in the treated groups of dogs. The urinary excretion of Pu 239 was increased in the treated dogs compared to the control dogs that inhaled the 325 degrees C and 600 degrees C aerosols and was low in all dogs exposed to the 900 degrees and 1150 degrees C treated aerosol particles. Ten bronchopulmonary lavage procedures removed a mean of 44% of the ILB of Pu 239 from the lungs. The aerosol temperature and resulting differences in solubility of the particles did not influence the efficacy of the lavage procedure. An in vitro solubility of the particles did not influence the efficacy of the lavage procedure. An in vitro solubility test predicted the relative in vivo solubility of the 4 aerosols. These results are discussed in relation to the choice of therapy and its timing. (Auth)

<157>
Muggenburg, B.A., J.A. Mewhinney, J.J. Miglio, and D.O. Slauson, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

Removal of Inhaled Americium 241 from the Beagle Dog by Lung Lavage: A Pilot Study. LF-49; Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 274-276), 384 p.

The purpose of this pilot study was to obtain information on the relative effectiveness of lung lavage and intravenous chelation therapy on the removal of Am 241 from the dog. Six Beagle dogs were divided into 2 equal groups; the first group was exposed by inhalation to monodisperse particles of Am 241, 1.8 um AD. The second group was exposed to a polydisperse aerosol. Two dogs in each group were treated by lung lavage on days 2 and 9 post-exposure and diethylenetriaminepentaacetic acid (DTPA) on days 1, 2, 3, 4, 7 and 9. Lung lavage treatment removed 24% of the initial lung burden of Am 241 and DTPA increased urinary excretion to more than 15% of the initial lung burden (ILB) during the 16 days of the study. Translocation of Am 241 to liver and skeleton occurred in the control dogs, 6 to 17% of the ILB, but less than 2% translocated to these organs in the treated dogs. (Auth)

<158>
Murray, R., H. Lisco, M. Bloom, and M. Heller, Not given. 1945, March 14

Effects of Product Administration Intramuscularly to Mice. CN-2740; Part of Monthly Health Report on Problems Relating to Product for Period Ending February 15, 1945, (p. 5-7).

Plutonium nitrate was administered intramuscularly, intravenously and subcutaneously to male mice at dose levels of 1.5 and 4.5 ug/g. Preliminary results indicate that intravenous Pu caused certain systemic lesions in the liver and spleen. The median lethal dose was between 0.6 and 1 ug/g, with median survival of 2-3 weeks. Intramuscular Pu showed no acute toxicity in doses up to 4.5 ug/g. Subcutaneous Pu caused systemic lesions, with the median lethal dose probably below 4.5 ug/g. Local lesions were observed with subcutaneous and intramuscular doses down to 1.5 ug/g. The histological effects of Pu in spleen and lymph nodes are discussed. (RAF)

<159>
Murray, R.G., Not given. 1948

The Thymus. Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 9. McGraw Hill Book Company, Inc., New York, New York, (p. 446-501), 808 p.

The thymuses of great numbers of rabbits, rats, mice, guinea pigs, and chickens were histologically examined following treatment internally with plutonium, radium, phosphorus 32, sodium 24, and fission products, or externally with fast or slow neutrons, beta rays, gamma rays, and x rays. Single and repeated doses were given. Comparable damage was done to the thymus in a variety of species by a similar number of R of single-treatment total-body x-rays, irrespective of the variations in LD 50/30 days for these species. Mice had small but otherwise apparently normal thymuses after as many as 20 daily 80-R total body doses of x-rays, although severe depletion occurred after 350 R given in a single dose, and slight damage after a single 80-R exposure. Zirconium 93 uCi/g and barium 140-lanthanum 140 (5 uCi/g) caused complete depletion of the rat thymus within 2 weeks. Intraperitoneal injection of 2.5 uCi/g of phosphorus 32 in mice did not deplete the thymus. A dose of 50 to 80 uCi/g of sodium 24 caused rapid and severe depletion without substantial recovery in 4 days, in a manner similar to that following a single dose of total-body irradiation with an external dsource. Intraperitoneal injection of 1.0 uCi/g of radium caused progressive severe depletion of the thymus of mice; definite depletion resulted in the thymus of rats from doses as low as 0.125 uCi/g. Plutonium was deposited irregularly in the thymus of rats. The autoradiograph of mice were entirely negative and there was no damage to the mice at any dose, whether injected intravenously

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or intramuscularly. The rats, on the other hand, showed considerable depletion of lymphocytes in some specimens; in others the thymus was unaffected. Areas containing plutonium were depleted, and adjacent uncontaminated areas were relatively normal. Damage was observed in one rat intravenously injected with only 0.008 uCi/g of plutonium. (Auth) (FMM)

Several histological sections are shown.

<160>
Murray, R.G., Not given. 1948

The Spleen. Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 7. McGraw Hill Book Company, Inc., New York, New York, (p. 243-347), 808 p.

The spleens of large numbers of rats mice, guinea pigs, and chickens were histologically examined after exposure to radiations from plutonium, radium, phosphorus 32, sodium 24, or mixed uranium fission products, or to externally applied fast neutrons, slow neutrons, beta rays, gamma rays, or x-rays. Single and repeated doses were given. Daily treatments of 80 R of total-body x-rays severely depleted the white pulp of the mouse spleen by 20 treatments, but erythropoieses was definitely elevated after 24 treatments. Greater depletion occurred after 350 R given in a single dose. Intraperitoneal injection of 5.6 uCi/g of barium 140-lanthanum 140 in mice caused rapid moderate depletion of the splenic white pulp; with complete recovery at 20 days and concomitant hyperplasia of ectopic myelopoiesis in the red pulp. Intracardial injection of 3.0 uCi/g of zirconium 93-niobium 93 caused more severe depletion of the splenic white pulp than even 14.0 uCi/g of barium 140-lanthanum 140. In further contrast to the other beta emitters studied, erythrophagocytosis in the red pulp was very striking, and extopic myelopoiesis was depressed, rather than elevated, as late as six weeks after treatment. Intravenously injected plutonium (0.08 uCi/g) caused only mild depletion of the white pulp of mice and hyperplasia of ectopic hematopoiesis in the red pulp, after a temporary depression of this function. Damage to white pulp was more severe in rats, being significant at doses as low as 0.03 uCi/g. Intramuscular injection of 0.3 uCi/g caused only slight hyperplasia of ectopic hematopoiesis. Damage to the spleen was somewhat less with radium injected intraperitoneally than with plutonium injected intravenously. Although 1.0 uCi/g of radium did considerably more damage in mouse spleen than 0.08 uCi/g of plutonium (these are roughly equivalent microgram amounts), 0.06 uCi/g of radium was less damaging than 0.03 uCi/g of plutonium in rats. Autoradiographs showed all materials more concentrated in red pulp than in the white pulp; the deposition frequently was especially heavy at the transition between these two zones. With zirconium 93-niobium 93, yttrium 91, and radium, however, there was some deposition in the white pulp, mostly around the arteriole. (Auth) (FMM)

Numerous histological sections are shown.

<161>
Nabors, C.J., Jr., D.L. Berliner, and W. Stevens, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1967, March 31

Preliminary Comparison of the Effects of Americium 241 and Plutonium 239 on Serum Enzymes. COO-119-236; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 207-217), 268 p.

Previous reports have described the effects of Pu 239 on serum enzymes in dogs. Elevated values for serum glutamic-pyruvic transaminase (SGPT) were found in 0.1, 1.0, 1.7 and 2.0, dose levels. The percent of measurements elevated increased with increasing dose. Also, Pu 239 produced increased serum alkaline phosphatase levels, with an increase in these levels from the 1.0 to the 5.0 dose level. A positive correlation between serum alkaline phosphatase and incidence of osteogenic sarcoma was seen at all but the 5.0 dose level. Increases in SGPT and alkaline phosphatase measurements correlate with the amount of radionuclide-induced hepatocellular necrosis. A small group of test dogs has been injected with Pu 239 at the 5.0 dose level and Am 241 at the 1.0, 2.0, 3.0, 4.0 and 5.0 dose levels. These animals were closely studied in the initial post-injection period. Both plutonium and americium were liver seeking nuclides. Increased SGPT and alkaline phosphatase levels have been observed in Am 241 bearing dogs as early as four months post-injection. Sixty percent more Am 241 than Pu 239 deposited in the liver, and the changes in serum enzymes corresponded to the increase in radiation dose to this organ. Pu 239 induced changes appeared at later times.. The values for changes in serum enzyme levels in Am 241 dogs and the distribution of Am 241 were compared with previous findings for Pu 239 induced liver damage. (Auth)

<162>
Nabors, C.J., Jr., W. Stevens, and R.E. Maxwell, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

Comparative Effects of Plutonium 239 and Americium 241 on Biochemical Parameters: Effect of Dose and Radionuclide Burden Time. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 87-104), 552 p.

A comparison of the effects of Pu 239 and Am 241 on serum biochemical parameters has been made using the technique of multiple regression analysis. A separate analysis was made of data from male and female animals with plutonium animals also being separated into tumor and non-tumor groups. Two major differences were evident: Am 241 appears to produce significant changes in SGPT and serum alkaline phosphatase at earlier times post-injection that Pu 239; male beagle dogs appear to be more susceptible to radiation-induced changes in SGPT, SGOT and serum alkaline phosphatase than females. The significance of these findings and their possible relationship to carcinogenesis and hormonal effects is discussed. (Auth)

Table 3 gives a tabulation of clinically diagnosed osteosarcomas in Pu 239-injected beagles.

<163>
Menot, J.C., P. Masse, and J. Lafuma, Centre d'Etudes Nucleaires, Departement de la Protection Sanitaire, Fontenay-Aux-Roses,

<163>

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ANIMALS

<163> CONT.
France. 1967

Metabolism of Plutonium. Radioprotection, 2(4), 297-312.(French)

Plutonium does not exist in an ionic form at physiological pH. It owes its chemical individuality to the fact of the possible coexistence of several valencies. The study of the general metabolism of Pu is based on the compounds because they allow the isotope to be obtained in a monodisperse form. Elimination is then a function of the stability in vivo of the compound. Two phenomena, cellular uptake and hydrolysis, intervene in the liberation of Pu in the organism. The study of the insoluble forms is more complex: a small percentage of local degradation follows the transport, with stoppage at the level of the ganglions and the reticuloendothelial system. The dissociated salts of Pu hydrolyze on the spot; a small fraction perhaps is taken up by the plasma proteins. The histological study shows that for the liver there is uptake by the kupffer cells and hepatic cells, for the bone, there is double retention by the medullary microphages and by the bony network and for the kidneys there is glomerular filtration and reabsorption with tubular precipitation. The metabolism of Pu is thus governed by the phenomena of hydrolysis, secondary degradation and cellular transport. (tr-FNM)

Table 2 shows distribution of insoluble Pu salts and metal after local injection. Table 1 gives the percentage of migration of Pu 239 injected muscularly in Pu(+4) DTPA, Pu(+4) EDTA, Pu(+3) protein, Pu(+4) citrate, Pu(+3) bicarbonate and Pu(+4) carbonate.

<164>
Menot, J.C., M. Morin, P. Massey, and J. Lafuma, Commissariat a l'Energie Atomique, Centre d'Etudes Nucleaires, Fontenay-aux-Roses, France. 1971, December

Metabolic Study of the Binding of Plutonium to Serum Proteins. CEA-R-4263; EUR-4712-f; 8 p. (French)

The metabolism of plutonium-transferrin complexes was studied in rats. Double labeling of transferrin by Fe 59 and Pu 239 demonstrated fast migration from the site of transmuscular administration, similar distribution patterns with either muscular or intravenous injections, the unbinding of the transferrin-plutonium complex and, above all, significant deposits of plutonium in bone. Using Pu 238, more accuracy still was achieved in the knowledge of the element distribution after intramuscular or intravenous injections of the transferrin-plutonium complex; within one week, 93% migrated from the site of intramuscular injections and 70% of the migrating fraction was deposited in bone. (Auth)

<165>
Nevstrueva, M.A., V.A. Kolotrin, P.E. Livshits, and V.M. Shubik, Institute of Radiation Hygiene, Leningrad, USSR. 1974, February

Effect of Incorporated Radionuclides on Immunity. CONF-730907<PART 1)1 Part of Snyder, W.S. (Ed.),, Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 141-146), 1475 p.(Russian, English Summary)

Data are reported from a study on immunologic reactors including nonspecific and specific immunity, and allergic and antiallergic reactivity following a single and chronic administration of radioisotopes (Sr 90, I 131, Co 137, Ce 144, Ra 226, Pu 239) to rats and rabbits. The differences of some radioisotopes and total irradiation effect on immunity are discussed. The dependence of immunological action upon biophysical properties of radioisotopes is postulated. (Auth)

<166>
Nolibe, D., Centre d'Etudes de Bruyeres-le-Chatel, Montrouge, France. 1973, January 22

Elimination of Inhaled Plutonium Oxide Particles by In Vivo Lung Washout. Comptes Rendus Hebdomadaires des Seances de l'Academie des Sciences, Serie D, 276, 681-684.(French)

As lung washout processes are only about 10% efficient, it is necessary to repeat the process several times. It was observed that the efficiency of the process becomes constant between the 10th and 40th day after contamination of the lungs of babcons (PAPIO PAPIO) with a 70 to 200 uCi per gram PuO2. During this delay period, repeated treatments can be carried out. On the other hand when higher doses are considered it is found that the efficiency of the treatment decreases rapidly. It is thus necessary to intervene within a shorter delay period. This last observation implies that the rate of lung washout treatments must be adapted to the dose inhaled. The results obtained in rats by lung lavage post morten also show that the efficiency of lavage as a function of time varies according to the lung dose. (France) (FNM)

<167>
Norris, W.P., and T.E. Fritz, Argonne National Laboratory, Division of Biolcgical and Medical Research, Argonne, IL. 1972

Interactions of Total Dose and Dose Rate in Determining Tissue Responses to Ionizing Radiations. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 243-260), 552 p.

Young adult beagle dogs of both sexes were exposed continuously to Co 60 gamma-rays at exposure rates ranging from 5 to 300 R/22 hour exposure day. The study has progressed to 1020 days of exposure. Three primary causes of death--septicemia, anemia, or myeloproliferative disease (MPD)--have been identified and related to exposure rate. At 30 R/day and above, all dogs died with septicemias associated with granulocytopenia. All three causes of death occurred among dogs given 17 R/day, with septicemic deaths preceding deaths from anemia, and death from MPD occurring even later. At either 5 or 10 R/day there were no deaths due to septicemia, and deaths from anemia always occurred earlier than deaths from MPD. The lowest exposure rate that produces septicemic death in the beagle is about 17 R/day, while the threshold exposure rate for anemic death is about 5 R/day. The minimum total exposure necessary to produce any of the three types of death seems to be about 2000 R. The authors attempted to demonstrate the relevance of these findings to the interpretation of radiation-induced effects

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<167> CONT.
from radionuclides deposited within the mammalian body. (Auth)

<168>
Osanov, D.P., F.B. Pershov, O.V. Klykov, and V.A. Rakova, Not given. 1971, May

The Kinetics of Dose Distribution in the Skin in Its Contamination with Radioactive Substances. Meditsinskaya Radiologiya, 16(5), 44-50. (Russian, English Abstract)

The paper deals with the results of experimental investigation of the kinetics of microdistribution in the skin of tritium oxide, Cs 137 and nitrates of Sr 89, Pu 239 and Am 241. The authors also present the obtained dose distributions in structural layers of the skin from these isotopes and discuss the correlation of doses, surface contamination and penetration into the skin of the activity. Eight weeks old swine at approximately twenty animals per isotope were studied. (Auth)

<169>
Park, R.Z., S.W. Whitson, and W.S.S. Jee, University of Utah, College of Medicine, Department of Anatomy, Salt Lake City, UT. 1972

Vascular Theory of Radiation Injury to Bone. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 305-322), 552 p.

The morphology of the contents of the haversian canals of cortical bone of old controls and irradiation-injured dogs was examined by electron microscopy. Tight junctions were found between mesenchymal cells, preosteoblasts and osteoblasts (a "functional" syncytium). This "functional" syncytium was postulated to be involved with coordinating the activities of cells, facilitating transport between cells and/or forming an extracellular space/bone barrier. Other findings included processes of pericytes juxtaposed to processes of perivascular cells and osteoblasts and osteocytes containing centrioles and microtubules. The order of decreasing radiosensitivity for cells in the haversian canal was endothelial cells, mesenchymal cells and osteoblasts. Irradiation-induced changes in endothelial cells included decreased numbers of pinocytotic vesicles, vacuolization, thickened and ragged basement membrane, increased numbers of inclusion particles and "blistering". Changes in perivascular cells included diminution in numbers of cells and increased lysosomal-like inclusions in the cells. Fibrosis was observed in the perivascular space. These changes were related to our working hypothesis of radiation-induced alterations in the transport of ions and molecules between blood and bone. (Auth)

<170>
Park, J.F., W.J. Bair, and W.J. Clarke, General Electric Company, Hanford Laboratories, Biology Laboratory, Richland, WA. 1964

Chronic Toxicity of Inhaled Plutonium in Dogs. CONF-656; Part of Proceedings of the 12th Annual Symposium of the Radiation Research Society held in Miami, Florida, May 18-20, 1964. Published in Radiation Research, 22(1), 222.

To study the long-term translocation and biological effects of inhaled plutonium, 40 beagle dogs were given single 10-30 minute exposures to Pu 239 PuO2 aerosols. Seven dogs died 28-48 months after deposition of 4-9 uCi in the lungs. The body burden at death was 1.5-3 uCi with about 50% of the body burden in the lung, and as much as 50% in the bronchial and mediastinal lymph nodes of some dogs. The liver contained 2-10% and the skeleton, 1-4%. The average radiaton dose to the lungs was 9,000-23,000 rads. The clinical signs prior to death were cardiopulmonary insufficiency and lymphopenia. In addition to severe fibrotic and metaplastic changes, four dogs surviving 36 months after exposure evidenced bronchiolo-alveolar tumors. Most of these neoplasms were locally invasive and of multicentric origin, and no evidence of regional or distant metastasis was seen. The plutonium distribution in the lung correlated with fibrotic, metaplastic and neoplastic lesions, and clinical cardiopulmonary symptoms indicated the lung was the critical organ causing death. (Auth) (Complete Article)

<171>
Park, J.F., D.L. Catt, D.K. Craig, R.J. Olson, and W.H. Smith, Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA. 1974, February

Solubility Changes of Plutonium 238 Oxide in Water Suspension and Effect on Biological Behavior After Inhalation by Beagle Dogs. CONF-730907 (Part 1); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 719-724), 1475 p.

Beagles were exposed to aerosols of Pu 239 PuO2 or Pu 238 PuO2 prepared by identical methods of calcining the oxalate at 750 degrees C for 2 hours. The PuO2 was stored in water suspensions of 2 to 3 mg PuO2/ml for various periods until required for exposure at which time suspensions of suitable concentrations were prepared by dilution of the stock. Aerosols were generated by nebulizing these suspensions. Ultrafilterability of the Pu 239 PuO2 suspension remained stable ranging from 0.1 to 0.2% over a 16 month period. Dogs exposed to Pu 239 PuO2 during this time and sacrificed 30 to 140 days postexposure had more than 98% of the body burden at death in the lungs and thoracic lymph nodes. Dogs exposed to Pu 238 PuO2 6 months after preparation of the stock suspension had 64% and 50% in the lungs and thoracic lymph nodes, with 23% and 34% in the skeleton and 8% and 11% in the liver at 30 and 90 days postexposure, respectively. Ultrafilterability of the stock 238Pu O2 suspension was 25%. X-ray diffraction analyses of the Pu 239 PuO2 and of freshly prepared Pu 238 PuO2 yielded the expected peaks, but the Pu 238 PuO2 that had been in water suspension for 9 months showed no X-ray peaks. Dogs exposed to freshly prepared Pu 238 PuO2 with 0.2% ultrafilterability showed more than 98% of the Pu in the lungs and thoracic lymph nodes 30 and 60 days postexposure, while the ultrafilterability of the water suspension changed from 0.2% to 16% during the 60-day post-exposure period. Radiation damage to Pu 238 PuO2 may be responsible for the differences in the behavior of Pu 238 PuO2 and Pu 239PuO2 in water suspension and in vivo. (Auth)

Table 2 shows tissues distribution of inhaled Pu in beagles, comparing aged and fresh Pu suspensions. Table 3 shows retention and excretion of inhaled Pu in beagles comparint

<171>

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<171> CONT.
aged vs. fresh Pu suspension. Table 5 shows tissue distribution of Pu in beagles after inhalation of Pu 238 O2 and Pu 239 O2.

<172>
Park, J.F., W.J. Clarke, and W.J. Bair, Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA. 1965

Plutonium Particle-Induced Neoplasia of the Canine Lung. 1. Clinical and Gross Pathology. BNWL-SA-230, CONF-650624; Part of Proceedings of the 2nd International Symposium on Lung Tumors in Animals held at Perugia, Italy, June 24-29, 1965, (20 p.).

Female beagle dogs 12 to 43 months old were given a single inhalation of plutonium oxide aerosol. They died or were sacrificed when death was imminent during the 3 to 5 yr post-inhalation period. The body burdens at death ranged from 0.9 to 2.7 uCi. The lungs and bronchial and mediastinal lymph nodes contained 76 to 95% of the body burden. Forty-two to 75% of Pu was in the lungs, while 17 to 49% was in the bronchial and mediastinal lymph nodes. The Pu in the liver ranged from 2-15%, and 1-5% of the body burden was in the bone. The average total radiation dose to the lung was estimated to be 9,000-23,000 rads. Cardiopulmonary insufficiency and lymphopenia were the primary clinical signs associated with severe fibrosis of the lung and bronchial lymph nodes. These organs contained 76 to 95 percent of the terminal body burden. Five of these animals showed primary pulmonary tumors. Three of the animals showed radiographic lesions suggestive of pulmonary neoplasia 4 to 9 months before death. The tumors were grossly multicentric in 2 of the 4 animals and metastases were not evident, however, microscopic examination indicated multicentric origin in 5 animals and metastases to the bronchial lymph nodes in 1 dog. Six of the 42 dogs exposed to Pu 239 showed bronchiolo-alveolar carcinomas, an incidence of 14 percent compared to a primary lung tumor incidence of 0.2 percent reported for canine necropsy material. (RAF)

<173>
Parkinson, J., University of Utah, College of Medicine, Radiobiology Division, Salt Lake City, UT. 1955, September 30

Plasma Fe Study. AECU-3109, Part of Semiannual Progress Report, (p. 71-73).

A study of plasma Fe values in normal beagle dogs was carried out followed by a toxicity study of dogs injected with various dosages of Pu, Pa, MsTh and RdTh. Large variations of plasma Fe were observed in normal dogs. In the animals administered Pa, MsTh, and RdTh cyclic fluctuations in the plasma Fe were noted in the early weeks after injection. Wide swings from subnormal to supernormal values were observed. These changes did not correlate with hematologic changes during this period. The Pu group did not show these changes. A preliminary report is given on a study dealing with potential anemia and decreased survival time of red blood cells produced by Pu, Pa, MsTh and RdTh in beagles. (RAF)

<174>
Persing, R.L., V.C. Forstman, and L.K. Bustad, Hanford Atomic Products Operation, Richland, WA. 1960, Janaury 15

Removing Plutonium Injected in Skin of Swine. HW-65500, Part of Kornberg, H.A., Hanford Biology Research Annual Report for 1959, (p. 72-73), 208 p.

Following intradermal administration of varying doses of Pu(+4) nitrate in swine, a lower retention (probably due to sloughing) was observed with high levels than with low levels. Suction cups applied to Pu-contaminated puncture wounds were ineffective in removal of the contamination. Preliminary observations indicate that tourniquets may aid in restricting translocation of Pu from contaminated sites. (Auth)

<175>
Pesternikov, V.M., 1972

Determination of Maximum Permissible Plutonium 239 Level According to the Osteosarcomogenic Effect. AEC-tr-7457, Part of Moskalev Yu.I. and Kalistratova, V.S. (Eds.), Biological Effects of Radiation from External and Internal Sources, (p. 391-397), 515 p.

A mathematical expression was obtained for the mean life expectancy of animals with osteosarcoma as a function of mean absorbed dose rate in the skeletal system, for different animal species (mouse, rat, dog). The slope of the curve (gamma) of the dose-effect function is inversely proportional to the mean survival of a given animal species. Estimated maximum ineffective absorbed dose rates in the skeletal system constitute 0.05 for mice, 0.012 for rats, and 0.002 rad/day for dogs. The estimated maximum ineffective plutonium level in the human organism constitutes 0.021-0.028 uCi, which is 1.5-2 times lower than the level approved by the International Commission on Radiological Protection as the maximum permissible level. (Auth)

<176>
Pesternikov, V.M., and Z.M. Bukhtoyarova, Not given. 1972

Dynamics of the Plutonium 239-Induced Osteosarcomas Growth Rate. Meditsinskaya Radiologiya, 17(3), 19-24. (Russian, English Summary)

Roentgenological findings were the basis for a quantitative assessment of osteosarcoma growth rate in rats following a single intraperitoneal administration of 2.5 mCi/kg of plutonium citrate. Most osteosarcomas do not originate at the sites of the highest isotope concentration. Some tumors showed a characteristic of primary multiple growth. Possible extrapolation for determining osteosarcoma development time is discussed. (Auth) (RAF)

<177>
Pierce, M., Not given. 1948

The Gastrointestinal Tract. Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 10. McGraw Hill Book Company, Inc., New York, New York, (p. 502-540), 808 p.

The gastrointestinal tracts of a large number of mice, rabbits, rats, guinea pigs, and chickens were histologically examined following treatment with externally applied

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<177> CONT.
x-rays, fast neutrons, slow neutrons, beta and gamma rays and internally administered plutonium, radium, sodium 24, phosphorus 32, and several of the radioactive products of uranium fission. After externally applied single treatments of about the LD 50/30 days (500 to 800 R) the changes were similar in mice, rabbits, rats, and chickens. Nuclear swelling, pyknosis, and fragmentation were marked as early as 3 hours in the gastric pits and intestinal crypts. Large doses (23 to 33 uCi/g) of fission-products mixture by gavage to rats caused extreme necrosis of the mucosa, most marked in the lower ileum and colon. Smaller single treatments of fission-products mixture or of yttrium 91 (5.0 uCi/g) or daily treatments with as high as 2.0 microcuries/g to rats for three months caused minimal changes. Among parenterally administered beta emitters, phosphorus 32 (2.5 uCi/g), yttrium 91 (2.0 uCi/g) and strontium 89 (3.6 uCi/g) produced moderate to mild damage, of decreasing severity in the order named. Parenterally administered sodium 24 (47 to 83 uCi/g), barium 140-lanthanum 140 (1.4 to 14.0 uCi/g), and especially zirconium 93-niobium 93 (3.0 to 7.0 uCi/g) caused severe damage to the gastrointestinal mucosa. These changes were marked in the first and second weeks following treatment. Changes in the gastrointestinal tract after parenteral administration of the alpha emitters (radium and plutonium) occurred at later intervals and lower doses than after the beta emitters. Damage was noted after 0.125 uCi/g of radium in rats, and 0.06 uCi/g of plutonium in rats. It was concluded that Pu was as toxic as Ra and probably more toxic when injected doses were compared on a microcurie/g basis. (Auth) (FMM)

<178>
Pohlit, W.E., and W. Schafer, Gesellschaft fuer Strahlenund Umweltforschung mbH, Frankfurt/Main, German Federal Republic. 1974

Recovery and Repair in Yeast Cells After Irradiation with Densely Ionizing Particles. CONF-731050 IAEA-SM-179/23; Part of Proceedings of a Symposium on the Effects of Neutron Irradiation Upon Cell Function held in Nuremberg, Germany, October 22, 1973, (p. 177-184).

A Cybernetic model has been developed for radiation effects in living cells. This model includes quantitative changes in radiation sensitivity with absorbed dose, recovery (split-dose reactivation) and repair (liquid-holding reactivation). The model has been tested extensively with sparsely ionizing radiations (x-rays and electrons) using diploid and haploid yeast cells. Experiments are described in which the model is used for analyzing irradiation with alpha particles from an americium source. These particles are representative for densely ionizing particles with known LET distribution of absorbed dose. It can be shown quantitatively how much the irreparable fraction of the radiation damage is increased in comparison with sparsely ionizing radiations. The quantitative data can be used to predict reactions of fast and slow neutrons of various energy distributions. The consequence of these results for radiation therapy with fast neutrons and for radiation protection are discussed. (Auth)

<179>
Prosser, L., Nature, 1945, February 12

Project Council Meeting, Biology Section, January 16, 1945. CS-1907; Part of Nickson, J.J., Health Information Meeting held January 16, 1945, (p. 3-6), 6 p.

The distribution of intravenously injected Pu(+6) nitrate in the blood plasma of a dog was investigated by means of the Tselius technique. The Pu was attached to the alpha globulin fraction. The first sign of clinical abnormality was a drop in white count. On the 16th day the count was 200. An elevation in temperature, and heart rate, and a fall in blood pressure were evident on the 13th day. The albumin and gamma globulin fractions remained unchanged in total quantity. The alpha and beta globulins altered markedly. There was also an apparent increase in fibrinogen. An essentially normal liver function was suggested. A mechanism similar to death caused by rays was suggested. In mice the 30 day 100% lethal dose with intravenous injection of the chloride was 1 ug, 0.5 ug produced only 10% death in 50 days under the same conditions. Radium in mice had essentially the same toxic levels as does Pu. In rats, Pu injected at the level of 2 ug produced 100% mortality in 30 days, 1.0 ug produced death in 25% under the same conditions. A marked difference in distribution of radium and Pu in bone was seen by studying the radioautographs. (HP)

<180>
Puzyrev, A.A., and A.P. Nifatov, 1972

Microdistribution of Americium 241 in Some Rat Organs Following Intraperitoneal and Intratracheal Administration of this Isotope. AEC-tr-7457, Part of Moskalev, Yu.I. and Kalistratova, V.S. (Eds.), Biological Effects of Radiation from External and Internal Sources, (p. 435-440), 515 p.

Investigations were conducted on 92 Wistar rats of both sexes, weighing 140-150 grams. A solution of Am 241 nitrate (pH 3.8) was administered intraperitoneally and intratracheally in a dosage of 7 uCi/kg. Three or four animals were sacrificed at each of the following intervals after administration. 1, 3, 6, 24 hours, and 3, 7, 14, 30, 90, 180, 270, and 360 days. Histoautoradiograms of soft tissues were prepared. Distribution of the isotope in bone tissue was studied on ashed and unashed sections of femur, rib, and vertebra. Histoautoradiograms of the liver of rats sacrificed 1 hr to 90 days after intraperitoneal administration of the isotope revealed essentially uniform distribution. After 6-12 months, most of the isotope was in the reticuloendothelial cells. The histoautoradiographic data pertaining to unashed bone showed that for first 7 days after administration, Am 241 concentrates chiefly on the active surfaces of bone at the site of formation of the osseous matrix. The nature of microdistribution of Am 241 at subsequent stages is related to processes of growth and reorganization of bone. In comparing the data with the literature, it is seen that at the early stages most of the Am 241 is concentrated in smaller epimetaphyseal areas, as compared to Pu 239. At later stages there is a decline in isotope content in the periosteum and accumulation in the periosteum. The microdistribution of Am 241 in the liver, kidneys, spleen and bone tissue is similar for both intratracheal and intraperitoneal administration. However, aggregation of the isotopes in the lungs occurred soon after

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<180> CONT.
intratracheal administration. Morphological changes developed at sites of accumulation characterized by inflammation and resulting in pneumosclerosis. The distribution of Am in Plymphatic tissue is predominantly different. (FMM)

<181>
Rehfeld, C.F., J.A. Plomquist, and G.N. Taylor, Argonne National Laboratory, Division of Biological and Medical Research, Argonne, IL; University of Utah, College of Medicine, Department of Anatomy, Salt Lake City, UT. 1972

The Beagles. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 47-58), 552 p.

The history of beagles as a research animal extends back only to the comparatively recent year of 1950. Starting at that time, the Radioficlogy Division at the University of Utah has had a major role in pioneering the in-laboratory breeding and care of beagles for research. This laboratory has produced 1427 beagles since 1950 with a total of 32 animals acquired for breeding purposes; each of 103 of the laboratory-bred beagles produced one or more young to contribute to this total. The descendents of 18 acquired and 21 laboratory-bred animals were favored in selection of successive generations of breeding stock. All of the 21 dogs were related to the original 18, so a large proportion of the colony dogs were directly related to them. Although a large number of the laboratory-bred beagles were inbred, in a majority (80.3%) of these, the inbreeding is less than that which would result from one sibling mating. This colony of beagles was started at a time when there were no large research dog colonies in existence and soon became a model colony within a prototype physical facility. (Auth)

<182>
Retherford, J.C., A.L. Brooks, and R.O. McClellan, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1973

Early Distribution, Retention and Cytogenetic Effects of 0.3 um Monodisperse Plutonium 239 Dioxide Particles in the Chinese Hamster. CONF-730431; Part of Proceedings of the 21st Annual Symposium of the Radiation Research Society held in St. Louis, Missouri, April 29-May 3, 1973. Published in Radiation Research, 55(3), 512.

Chinese hamsters were intravenoulsy injected with monodisperse 0.3 um Pu 239 PuO2 particles labeled with Cr 51. Twenty-four animals were injected at each activity level of 2 x E(10-3) and 6 x 10(E-5) uCi Pu 239/g body weight. Four animals at each activity level were sacrificed at 0, 2, 4, 8 16 and 32 days post-injection. The Pu 239 was avidly retained with a slight decrease by 32 days to 94% of the initial activity. At all sacrifice times, the liver, spleen and remaining carcass contained about 90%, 20% and 8.0%, respectively, of the sacrifice body burden. The activity per gram of tissue was about equal for the liver and spleen, indicating equal competence of the reticulcendothelial system in these two organs and an equal dose commitment. To determine the amount and distribution of the cytogenetic damage to the liver cells, additional hamsters were injected with six graded activity levels from 6 x 10(E-5) to 6 x 10(E-3) uCi Pu 239 PuO2/g body weight. These activity levels were calculated, on the basis of the number of particles present, to irradiate 3 to 100% of the liver. Analysis at 6, 15 and 42 days has shown an increase in chromosome aberration frequency with time and with activity. (Auth)

<183>
Rhoades, R. P., Not given. 1948

The Vascular System. Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 16. McGraw Hill Book Company, Inc., New York, New York, (p. 712-735), 808 p.

The early changes in blood vessels were all qauntitatively alike in animals treated with any one of the following agents: internally administered Pu citrate or nitrate, Sr 89, Y 91, Ba 101-La 140, Ce-Pr (275 day), Zr 93-Nb 93; and externally applied fast neutrons, slow neutrons and gamma rays from Ra. The autoradiographs showed that Pu was deposited chiefly in the small vessels and apparently caused damage in them. It was thought that alterations in the blood vessels of irradiated animals was probably secondary to the course of inflammation of the surrounding connective tissue. The heart was found to be resistant to all the types of radiations considered. However, the hearts of radium-injected rats showed deposits of radioactive material which damaged them, although the myocardium itself remained unaltered. (FMM)

<184>
Rhoades, R.P., Not given. 1948

The Lung. Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 15. McGraw Hill Book Company, Inc., New York, New York, (p. 704-711), 808 p.

Rats, mice and rabbits were injected with Sr 89 in amounts varying from 0.28 to 14.5 uCi/g. Other series of animals were variously treated with P 32, Ba 140-La 140, Na 24, fission products mixture, Ra, Ce-Pr (275 day), Y 91, Zr 93-Nb 93 and Pu. Mustard gas was injected intravenously into a small series of rabbits. The lung tissue of a few rats was studied following inhalation of Y 91, Ce-Pr (275 day) and Pu. These rats received 28 or 220 microcuries/rat of Y 91, 50 uCi/rat of Ce-Pr, or 1.5 to 31.5 uCi/rat of Pu. In a specimen from a rat sacrificed one month after inhalation of Pu, the growth of epithelial cells appeared suggestively neoplastic. One of the three rats killed six months after inhalation of Ce-Pr appeared normal; the other two contained extensive epithelial cell proliferation. The effects of irradiation of rat lungs by internal sources was marked by the almost universal occurrence of abscesses in both the control and treated rats. Abscesses in the lungs of rats that inhaled radioactive substances differed from the abcesses in untreated rats by a proliferation of epithelium that was possibly neoplastic. Mice injected parenterally with radioactive isotopes showed no changes in the lungs which could be attributed to irradiation. The effects of x radiation, neutrons, and beta rays from P 32 were also reported. (FMM)

<185>
Rhoades, R.P., Not given. 1948

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<185> CONT.
Structures Accessory to the Gastrointestinal Tract. Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 11. McGraw-Hill Book Company, Inc., New York, New York, (p. 541-549), 808 p.

The livers of rabbits, rats, mice, guinea pigs, and chicks were examined after total-body x irradiation in doses ranging from 25 through 1,200 R, and the liver of two amphibians, Amphiuma and Triturus, after exposure to doses as high as 6,000 R. Guinea pigs were exposed to gamma irradiation from an external radium source, and mice were exposed to slow and fast neutrons. Except in the Amphiuma and the three-week chicks, no alterations consistent with treatment were seen in the liver. The effects on the species given various radiations from internal sources were the same as in those treated externally, except in the chick, Triturus and Amphiuma. In addition, autoradiographs were made from several specimens of many of the series. The distribution of the radioactivity in the liver was diffuse and homogenous for all the internally administered agents (Y 91, P 32, Ce-Pr, Ba 140-La 140, and Sr 89) except plutonium and radium. Injected plutonium, however, tended to gather into clumps. In the autoradiographs of mouse livers at 6 hours through 42 days after intravenous injection of plutonium, the shadows changed from a relatively diffuse pattern at 6 hours to one showing small dotlike accumulations, these increased in size until at 42 days the agent was agglomerated in masses. In the livers of animals given radium, which emits alpha, beta, and gamma particles, or fission-products mixture, the distribution picture showed a general diffusion with small round concentrations scattered throughout the organ. Despite the deposition of radioactive materials within the liver tissue, morphological alterations were slight in all specimens except in the rats injected with plutonium. Excessive vacuolization of the protoplasm, an enormous increase in cellular and nuclear size, characteristic clumping of nuclear material, and abnormal mitoses were noted. After various forms of irradiation in amounts ranging from 10 to 1,100 R or more from both internal and external sources, no changes were seen among the acinar or islet cells of the pancreas. Plutonium administered intramuscularly was not laid down in the pancreas, but intravenously injected specimens were positive. (PMM)

<186>
Richmond, C.R., and P.L. Thomas, Los Alamos Scientific Laboratory, Los Alamos, NM. 1974

Plutonium and Other Actinide Elements in Gonadal Tissue of Man and Animals. LA-UR-74-1314, 27 p.

This report summarizes available information on the gonadal content of mammalian species given various actinide elements by various routes of administration. Emphasis is placed on plutonium. Also discussed is the contemporary level of plutonium from nuclear weapons fallout in human subjects. The fraction of the administered burden of plutonium found in the gonads (FABG) of five mammalian species following intravenous injection was about 3 x 10(E-4) with only about a factor of 10 between the highest and lowest values to allow for differences between sexes, among species or as a function of time following injection. FABG values tend to be smaller in the female, as compared with the male, and following inhalation or subcutaneous implant. Data on the FABG for other actinides are qualitatively similar to that for plutonium. The gonadal plutonium concentrations from fallout in the United States residents are about 0.5 pCi/kg, not unlike that reported for other soft tissues, except thoracic lymph nodes, and bone. (Auth)

This report will also be published in Health Physics, 1975.

<187>
Rosenthal, M.W., Argonne National Laboratory, Division of Biological and Medical Research, Argonne, IL. 1961

Long-Term Effects of Therapeutic Removal of Internally Deposited Plutonium. ANL-6637, Part of Proceedings of the 7th Annual Symposium on Bioassay and Analytical Chemistry held in Argonne, Illinois, October 12-13, 1961, (p. 9-11), 100 p.

Mice were treated once a day with an interperitoneal injection of Ca DTPA (500 mg/kg) or saline. Therapy was initiated three days after administration of 2.6 uCi/kg of polymeric form of plutonium and given for 1 to 12 days. The mice were allowed to live until moribund, when they were sacrificed and autopsied, and roentgenograms were taken of the skeletons. Other mice, used for analysis of plutonium content and autoradiograms, were sacrificed serially. The amount of plutonium in the bone was reduced by about one-half and that in the liver by about one-third in mice receiving optimal DTPA therapy (for 12 days). Correlated with this removal of plutonium from the skeleton, bone-tumor incidence was also reduced by one-half, using as an index the proportion of mice in each group to develop bone tumors. In addition, the survival of the plutonium-poisoned mice was significantly increased by DTPA therapy for 8 to 12 days. For example, the mean survival time in these two combined groups was increased by 54 days to 450.2 plus or minus 8.5 days in comparison with that in controls, which was 396.5 plus or minus 8.5 days.

<188>
Rosenthal, M.W., Argonne National Laboratory, Argonne, IL. 1965, December

Effects of Experimental Alteration of Phagocytic Activity on Tissue Uptake and Retention of Polymeric Plutonium. ANL-7136, Part of Biological and Medical Research Division Annual Report, 1965, (p. 194-196), 342 p.

A colloidal form of Pu (30% ultrafilter) 0.1 uCi per mouse, was administered intravenously to 10 1/2-week-old mice at a time when the reticuloendothelial system (RES) was optimally stimulated with glucan or depressed with carbon or methyl palmitate. Five days after the injection of Pu, the liver contained the same amount of Pu in both groups of RES-depressed mice. Mice previously treated with methyl palmitate had 30% more Pu in the bone and 15% less in the marrow than in controls. Mice pretreated with colloidal carbon showed no significant change in the amount of Pu in the bone, but had 50% and 26% more Pu than the controls in the spleen and bone marrow respectively. Mice in which the RES had been stimulated with glucan prior to Pu administration showed no differences from controls in the Pu content of liver, spleen, bone marrow or bone at 5 days. Glucan treatment initiated 5 days after injection of polymeric Pu was followed

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<188> CONT.
by a decrease in the Pu content of the liver. This depletion of colloidal Pu in the liver by glucan stimulation of the RES, if confirmed, may be useful in combination with chelation therapy, which should prevent translocation to bone and promote excretion. (FMM)

<189>
Rosenthal, M.W., J.F. Fried, A. Lindenbaum, and J. Schubert, Argonne National Laboratory, Argonne, IL. 1961, November

Progress Report: Plutonium Removal, Tumor Incidence Studies. ANL-6464; Part of Biological and Medical Research Division Semiannual Report, January through June, 1961, (p. 82-84).

Progress is reported on the experiment to correlating tumor incidence with the degree and pattern of removal of Pu from mice by delayed therapy with DTPA. Daily injection of 500 mg/kg DTPA or of saline were begun 3 days after injection of Pu 239 citrate, 2.6 nCi/kg, and continued for from 1 to 12 days. Each mouse was allowed to live until moribund, when it was sacrificed and autopsied and a roentogenogram was taken of the skeleton. The mean death time for the mice given Pu and saline (controls) were 396.5 days after injection, and all the mice were dead by 515 days. DTPA therapy for either 8 or 12 days significantly increased the survival. Delayed DTPA therapy can increase the mean survival time by at least 50 days or by 13% of the control value. Survival of mice given DTPA for shorter periods was unchanged from that of the controls. In each group, the proportion of the mice in which at least one bone tumor appeared, has been tabulated as a preliminary index of the effectiveness of DTPA therapy. The incidence of bone tumors are reduced by about one-half by the 12-day course of DTPA therapy. Shorter periods of DTPA therapy had, in general, less effect on the bone tumor incidence. Histological identification has increased the number of malignancies discovered over that found by x-ray alone. The ratio of tumor incidence between control and treated mice, however remained 2:1 (62% in control, 33% in treated). The preliminary results indicate that a significant reduction in bone tumors by DTPA therapy will be shown, and it is indicated that this reduction can be correlated with the degree of removal of the Pu from the bone by DTPA. (FMM)

Table 27 shows mortality of Plutonium-injected mice, Figure 21 shows reduction of bone tumor incidence by DTPA in Pu-injected mice at 515 days.

<190>
Rosenthal, M.W., and A. Lindenbaum, Argonne National Laboratory, Division of Biological and Medical Research, Argonne, IL. 1972

Effectivenss of Different Therapeutic Regimes of Glucan in Removal of Polymeric Plutonium from the Mouse Liver. Radiation Research, 51, 541.

We have previously shown that the effects of the reticulcendothelial stimulant glucan and of DTPA are additive in removing polymeric plutonium from the mouse liver. Glucan appears to act upon intracellular hepatic plutonium, unavailable to DTPA. To determine the optimal time, schedule, and dose for glucan therapy, preliminary to its use in larger animals, mice injected intravenously with mid-range polymeric plutonium were given different regimes of glucan in conjunction with continuing DTPA therapy. An intravencus dose of 60 mg/kg of glucan removed the same fraction of injected plutonium from the liver by 47 days (8.0-9.5%) whether it was administered in a single injection 3 hours or 5 days before, or 5 days after plutonium, or divided and given on 3 consecutive days beginning 5 days after plutonium. Thus glucan apparently makes effective intracellular contact whether it reaches the liver cells before or several weeks after the plutonium. A dose of 15 mg/kg of glucan was almost as effective as 60 mg/kg. Since this low dose does not induce a significant increase in liver or spleen weight, reticuloendothelial stimulation may not be a prerequisite for plutonium removal. Injection of a second 60 mg/kg dose of glucan, 6 weeks after the first, removed a small additional amount of hepatic plutonium by 90 days. This suggests that intermittent administration of low levels of glucan may be a useful therapeutic procedure. (Auth) (Complete Article)

<191>
Rosenthal, M.W., and A. Lindenbaum, Argonne National Laboratory, Argonne, IL. 1965, December

Metabolic and Therapeutic Studies of Plutonium. ANL-7136; Part of Biolcgical and Medical Research Division Annual Report, 1965, (p. 192-193) 342 p.

A progress report is presented for several experiments. Retention data t 90 days are reported for mice administered three different forms of Pu of increasing degrees of polymerization (90, 30, and 17.5% ultrafilterable). It is seen that the liver content of Pu was reduced in all groups, but the degree of reduction (91%, 46% and 34% respectively) decreased with increasing polymerization of administered Pu. The marrow concentration of Pu remained the same in mice receiving the two most polymerized forms of Pu, but in those receiving the monomeric form there was greater than twofold increase at 90 days. Mice receiving the two most polymerized forms also showed little or no loss of isotope from the femur or tibial shaft. The reduction oflifetime incidence of bone tumors following reduction of the skeletal burden of Pu by chelation therapy with DTPA has been reported previously. This reduction was proportional to the amount of skeletal Pu removed in case of Pu administered in the polymeric form but not in the case of the monomeric form. It was suggested that the monomeric form was a more carcinogenic agent. Microscopic studies of standardized skeletal areas of mice receiving either polymeric or monomeric Pu, without DTPA therapy, have been prepared for the detailed studies of the carcinogenic process following both forms of Pu. In another experiment, therapy with DTPA alone following administration of monomeric Pu in mice reduced the skeletal content by 65%, whereas administration of both Vitamin A and DTPA reduced the skeletal Pu by 73% or almost to 1/4 of the control level. The practical usefulness of Vitamin A is however limited by the severity of its physiological effects. (FMM)

<192>
Rosenthal, M.W., J.H. Marshall, and A. Lindenbaum, Argonne National Laboratory, Argonne, IL. 1968

Autoradiographic and Radiochemical Studies of

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<192> CONT.
the Effect of Colloidal State of Intravenously Injected Plutonium on Its Distribution in Bone and Marrow. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2, Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 73-80), 680 p.

Radiochemical and autoradiographic evidence is presented showing that there is appreciable deposition of plutonium in bone marrow six days after intravenous injection into mice, which remains for at least three months. The amount of plutonium in the marrow, and its degree of aggregation, are greater, and the amount of plutonium on bone surfaces is smaller, after injection of polymeric than monomeric plutonium. Although the amount of plutonium in the marrow is appreciable, it is always less than that deposited on the bone surfaces. (Auth)

Table 1 shows the distribution of three forms of plutonium after intravenous injection of 0.1 uCi in liver, spleen, femurs and tibial shaft of mice.

<193>
Rosenthal, M.W., and Y. Ranman, Argonne National Laboratory, Division of Biological and Medical Research, Argonne, IL. 1973

Improved Removal of Plutonium from Mice by Encapsulation of DTPA Within Liposomes. CONF-730431, Part of Proceedings of the 21st Annual Symposium of the Radiation Research Society held in St. Louis, Missouri, April 29-May 3, 1973. Published in Radiation Research, 55(3), 515-516.

The chelating agent diethylenetr aminepentaacetic acid (DTPA) was encapsulated within artificial lipid spherules called liposomes. Liposome-encapsulated DTPA (80 or 100 mg DTPA/kg) and/or non-encapsulated DTPA (100 mg/kg) were injected into mice 3 days after administration of mid-range polymeric plutonium. In two experiments, liposome-encapsulated DTPA removed from 20 to 40% of the plutonium in the liver not removed by non-encapsulated (conventional) DTPA therapy at 6 to 10 days after plutonium administration. A second injection of liposomal DTPA, given 3 days after the first, or administration of both encapsulated and non-encapsulated DTPA, did not remove significantly more plutonium from the liver. The additional plutonium removed from the liver by liposome-encapsulated DTPA appears to be excreted in the urine. Both liposomes and polymeric plutonium in rats are associated with the lysosomes in liver cells. We suggest that the liposomal DTPA, released by lysosomal enzymes, removes from the liver both extracellular plutonium, and intracellular plutonium not avilable to the conventional DTPA therapy. Liposome-encapsulated DTPA was also more effective than conventional DTPA therapy in removing plutonium from the skeleton, at least a 1.6-fold greater removal from the femurs and a 2-fold greater urinary excretion of plutonium were found. The second injection of liposomal DTPA removed an additional fraction of Pu from the bone; this fraction was found in the urine. (Auth) (Complete Text)

<194>
Rosenthal, M.W., M. Snoler, and A. Linnenbaum, Argonne National Laboratory, Argonne, IL. 1968

Combined Reticuloendothelial Stimulation and Long-Term, Intermittent DTPA Therapy in Poisoning by Polymeric Plutonium. CONF-670521, Monographs on Nuclear Medicine and Biology, No. 2, Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 403-412), 680 p.

Mice were given a single intravenous injection of 0.1 or 0.2 uCi of polymeric plutonium, about 30% ultrafilterable, and ungraded as to particle size. Beginning five days later they were given 40 mg/kg of the reticuloendothelial system stimulant glucan, once daily for three days, or 500 mg/kg of DTPA once every three days for 28 injections or both treatments. In mice given glucan alone there was no effect on the plutonium content of any tissue at the height of the reticuloendothelial stimulation. Near the end of the period of stimulation (41-49 days after plutonium), the liver content of plutonium was lower (by about 10% of the injected dose) than the level in controls, and the bone content was increased by about the same amount. In mice given DTPA alone the liver content of plutonium was reduced by about the same amount, and the bone burden was reduced to 30% of the control level by 69 days. Combined, the two treatments had a nearly additive effect in reducing the liver burden and the same effect in bone as DTPA alone. Autoradiograms of livers showed that both glucan and DTPA reduced the concentration of plutonium in the hepatic parenchyma to a greater extent than in the sinusoidal areas. Concentrations of single alpha tracks and of stars, representing larger plutonium deposits, were reduced. In addition, in glucan-injected mice either with or without DTPA, the plutonium aggregates appeared more diffuse and disorganized than normal. These results suggest that these glucan-induced aggregates break up easily and permit more plutonium to be removed by natural mechanisms or therapeutic agents such as DTPA. (Auth)

<195>
Rouvroy, H., Commissariat a l'Energie Atomique, Centre d'Etudes, Bruyeres-le-Chatel, France. 1970

Study of Possible Changes Brought About by Plutonium Oxide in the Phosphatasic Acid Activity of Alveolar Macrophages of the Rabbit. CEA-R-3978; 96 p.(French, English Summary)

The report describes the various techniques used for determining the phosphatasic acid activity of alveolar rabbit macrophages after inhalation of radioactive plutonium oxide particles, exposure of the animals, removal and sampling of the alveolar cells, and technical dosage. The results obtained are presented, they do not make it possible, in this particular case, to affirm that an important change in the enzymatic activity studied occurs (Auth)

<196>
Rudnitskaya, E.I., Not given. 1972

Some Aspects of Thyroid and Parathyroid Damage Due to Americium 241. AEC-tr-7457, Part of Moskalev, Yu.I. and Kalistratova, V.S. (Eds.), Biological Effects of Radiation from External and Internal Sources, (p. 486-490), 510 p.

<196>

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<196> CONT.
After intravenous administration of Am 241 chloride into albino rats, in the dose range of 0.2E-0.002E uCi/gram, an aggregation of Am 241 particles was observed in the thyroid cartilage, starting on the 3rd day. Impaired blood and lymph circulation and colloid edema of the stroma was noted. The radionuclide was present in the thyroid and parathyroid in a finely dispersed form at all examination times. An increase of clear cells (parafollicular) was noted, starting on the 3rd day. Focal clear-cell hyperplasia, pyknosis and enlargement of some cell nuclei in the parathyroid was observed. By the 100th day indications of hyperactivity were seen in the thyroid and formation of papillomatous processes protruding into the lumen of some follicles. (RAF)

<197>
Russell, J.J., and A. Lindenbaum, Argonne National Laboratory, Division of Biological and Medical Research, Argonne, IL. 1973

Autoradiographic Localization and Quantitation of Articles Deposited in the Liver. CONF-730431; Part of Proceedings of the 21st Annual Symposium of the Radiation Research Society held in St. Louis, Missouri, April 29-May 3, 1973. Published in Radiation Research, 55(3), 513.

In cases of exposure to plutonium or other hazardous actinides, bone is considered to be the critical organ. There is mounting evidence that accumulation of Pu in the liver may also be of concern for long-lived species such as man. A serious problem wtih internal emitter--especially with radionuclides that are easily hydrolyzed and discretely deposited in the tissues--is how to calculate the true dose received by the exact region of the tissue in which deleterious effects will subsequently appear. Quantitative autoradiography could provide one approach to this problem. By measuring the concentration of alpha tracks formed in different regions of the liver, values can be obtained for the amount of Pu associated with parenchymal and sinusoidal cells, as well as the degree of variation in Pu concentration in different tissue regions. In this paper we recompute autoradiographic data from metabolic experiments carried out in mice and dogs injected either with monomeric or polymeric Pu 239 or with polymeric Am 241. The normalized data, expressed as tracks/dpm vs. days of autoradiographic exposure, demonstrate that track counts obtained after varying exposure times, and under a wide range of experimental conditions, are a reasonably valid measure of the amount of deposited actinide in the entire liver. By extension, valid assays of Pu or Am deposited at specific hepatic micrologi are obtainable. Data also are presented to demonstrate species differences in the retention of both forms of Pu associated with parenchymal cells of the dog liver, as compared to mouse liver. (Auth) (Complete Article)

<198>
Rysina, T.N., Not given. 1960

Plutonium Distribution and Excretion in Dogs at Different Periods of Time. Meditsinskaya Radiologiya, 5(11), 49-53.(Russian, English Summary)

A study was done on plutonium distribution and excretion in dogs following a fourfold intravenous administration of Pu(NO3)4, totalling 0.2 uCi/kg. Three months after the 4th injection 73% of plutonium was found in the organism, of which 40% was in the skeleton and 30% in the liver. During the subsequent 1 1/2 years the plutonium level in the body remained unchanged, except for its discharge from the spleen. By the end of the 3rd year of observations the amount of the radioactive element decreased in all tissues, including the skeleton and liver. The total decrease thereof in the body comprised 17% of the dose introduced initially. Plutonium excretion was studied within the space of one year and nine months. It reached its peak value during the first 3-4 days following injection (1.42-0.19%), then, at the end of the 2nd year it gradually diminished down to 0.005%. Beginning with the 2nd week after introduction and throughout the first 6 months it was being excreted in equal proportions in urine and feces. But later on, the amount of plutonium carried by feces was 1.5-2 times lower than that excreted in urine. A possible method is shown which enables an approximate estimation of plutonium level in the organism to be made by taking account of its activity in the excreta. (Auth)

<199>
Sanders, C.L., Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1968

Phagocytosis and Translocation of Plutonium 239 PuO2 Particles by Peritoneal Phagocytes of the Rat. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 81-90), 680 p.

Female, Sprague-Dawley rats (275-390 g body weight) were given intraperitoneal injections of 1-2 uCi Pu 239 PuO2 with 7-9 x 10(E+6) particles/uCi count mean diameter of about 0.1-0.2 u and a range of 0.02-7.00 u diameter. Intraperitoneally deposited Pu particles were translocated mainly into the mesentericomental region at five to seven hours after particle administration. Phagocytosis of deposited particles was the prime factor involved in the removal of particles from the peritoneal cavity. Significant direct penetration of the peritoneum by particles had probably also occurred during the first hour. Phagocytic and translocative rates were related to particle size. (RAF)

Photomicrographs (at x560 magnification) are given of peritoneal phagocytes after Pu 239 PuO2 administration.

<200>
Sanders, C.L., and R.R. Adee, Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA. 1969, October 6

The Ultrastructure of Mononuclear Phagocytes Following Intraperitoneal Administration of Plutonium 239 PuO2. Journal of the Reticuloendothelial Society, 6, 1-23.

The ultrastructural changes in rat peritoneal phagocytes during the first 7 days after intraperitoneal administration of plutonium dioxide, uranium dioxide, and latex particles are described. Female albino Sprague-Dawley rats (280-360 g body weight) were injected with 1.4 uCi Pu 239 PuO2 particles (count

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mean diameter, 0.12 u) suspended in zinc saline. Other rats were injected with thorium oxide (8 mg, approximately 30 mu diameter, thorotrast or 25 mg), latex particles (mean diameter 0.13 u) or saline. The animals were sacrificed at 2, 3, 6 hours and at 1 and 7 days after injection. The results show that numerous particles were localized within cytoplasmic vacuoles of phagocytes. The subcellular localization of plutonium particles was demonstrated by electron microscopic autoradiography. Only minimal alterations were found during the 6-hour period after plutonium. Significant alterations found at 1 and 7 days after plutonium included a marked increase in phagocyte size, and increased number of "pseudopodial" propections, necrosis of peritoneal cells and their subsequent engulfment by phagocytes. Plutonium and thorium particles were found lining the interior surface of lysosomes at 7 days. No significant degeneration of peritoneal phagocytes was observed at 7 days after thorium or latex. Phagocytes exhibited a relative radioresistance to alpha irradiation from plutonium particles. (Auth) (FMM)

<201>
Schubert, J., Argonne National Laboratory, Lemont, IL. 1951

Radioelement Removal by Chelating Agents: Application by Mass Action Laws and Other Factors. Federation Proceedings, 20, 219-220.

The idea is expressed that chelating agents do not work as well as a substance that fixes the toxic metal at the site of its deposition. Results are cited of treatment of beryllium poisoning with two identical chelating agents, except that one has a sulfonic acid group. When these drugs are given 4 hours after administration of Be, both compounds cause the same marked increase of excretion of Be, but one protects and one does not. The difference lies in the fact that the less water soluble form inactivates a greater fraction of the toxic metal within the tissues. The failure of BAL in radioelement removal is explained by the fact that practically all the radioelements of importance do not react with sulfur ligand atoms, namely Pu, alkaline earths and rare earths. Under physiological conditions there is no stable complex formed, and therefore, except for Po, BAL will be ineffective. A convenient way of testing the effect of chelating agents is mentioned, that is, to inject the radicelement into the animal and then withdraw samples of blood containing the radioelement. To the blood, one can then add the known amounts of chelating agents and measure the ultrafilterability. It is pointed out that when elements widely scattered in their hydrolytic reactions such as Hg, Ce and Sr are being compared, one has to insert additional terms, such as the hydroxylatin constants in order to have good correlation. From mass action considerations--omitting nonequilibrium processes--it is possible to estimate the fraction of radioelement bound by the legands involved. Several equations are derived. The importance of acertaining the degree of removal of a radioelement from specific cell fractions is mentioned. While it is possible to remove many radioelements from the body, it is also important to demonstrate that such removal also reduced the tumor incidence which follows much later. In long term experiments, it was found that removal of Pu effected by DTPA treatment given 3 days after injection or Pu caused a marked decrease in bone tumor incidence. (FMM)

<202>
Schubert, J., University of Pittsburgh, Department of Radiation Health, Pittsburgh, PA. 1972

Radioelement Metabolism and Decorporation as Influenced by Chelation and Mixed Complexes--Rapid Experimental and Calculative Approaches to Predict In Vivo Behavior. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 355-376), 552 p.

The solution chemistry and metabolism of radioelements (radioactive metal ions) are closely interrelated. The relative effectiveness of different chelating agents for the decorporation of radioelements deposited in mammalian tissues can be simply and rapidly determined by ultrafilterability or dialysis of tissues homogenized or minced in the presence of different concentrations of a given chelating agent. It is pointed out that apparent lack of agreement between the in vitro and in vivo observations are due to deficiencies in experimental design and interpretation, e.g., the use of a single, very high concentration of chelating agent, and neglect of the fact that a chelating agent with strongly hydrophilic groups, such as sulfonic acid, is less able to make contact in vivo with deposited radicelements. The role of mixed complexes in improved decorporation therapy is described. In particular, it is pointed out that generally two or more complexing or chelating agents will bind a metal ion more firmly than a single agent (e.g., MAB is twice as stable as MA2 or MB2 on statistical grounds alone). The response of monomeric and polymeric radioelments to chelating agents in decorporation therapy is shown to depend on the fact that the rate of depolymerization of the polymer by the chelating agent is much slower than the rate of formation of the chelate from the monomeric form. A simplified method for estimating the degree to which a chelating agent binds a radioelement in vivo is described. The method employs the so-called "conditional" or effective constant and side-reaction coefficients. It is also pointed out that the slope of the ascending and descending branches of the urinary or tissue excretion curves of a radioelement following chelation therapy can be utilized to determine the physico-chemical state of radioelements deposited in the body (i.e., the degree to which the radioelement is in a monomeric or polymeric state). Such information can be useful for prognosis and for determining schedules of treatment. (Auth)

<203>
Schwartz, S., R. Zagaria, and C.J. Watson, University of Chicago, Metallurgical Laboratory, Chicago, IL. 1947

Studies of Porphyrin Metabolism. 4. The Effect of Irradiation on Coproporphyrin Excretion. MDDC-1221; 18 p. (Declassified August 8, 1947)

The effect of radiation exposure on coproporphyrin excretion has been studied in 38 dogs. Some dogs were exposed to single doses of 400 to 450 R, 300 to 350 R, and 100 R total body x radiation and some to 50, 40, 25, 12.5 R daily x-ray exposure. Strontium 89 was injected at a concentration of 3.13 ug/kg and 2.87 ug/kg. Lethal doses of Pu

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<203> CONT.
(0.48 ug and 0.766 ug Pu/kg body weight) were injected intravenously and 0.404 ug Pu/kg was injected intramuscularly. A diminshed excretion of coproporphyrin in urine and feces was found to follow the administration of lethal or nearly lethal doses of total body x ray, Sr 89, and Pu. In most instances, a sharp increase in porphyrin excretion occurred during the terminal period. Preliminary studies showed no significant change in the ratio of the 2 coproporphyrin isomers (1 and 3) following irradiation. (Auth) (RAF)

All data obtained are illustrated in terms of the percent deviation of the per diem coproporphyrin excretion from the average control value for each dog.

<204>
Scott, K.G., D. Axelrod, J. Crowley, and J.G. Hamilton, University of California, Medical School, Divisions of Radiology and Medicine, San Francisco, CA; University of California, Crocker Laboratory, Division of Medical Physics, Berkeley, CA. 1949

Deposition and Fate of Plutonium, Uranium and their Fission Products Inhaled as Aerosols by Rats and Man. Archives of Pathology, 48, 31-54.

The purpose of these experiments was to ascertain the possible hazard resulting from inhalation of fissionable materials and fission products. Aerosols of plutonium (Pu nitrates and Pu oxides), uranium plus fission products, and protactinium were administered to rats. A Zr 89 aerosol was administered to a human subject and to rats. Aerosols of the aforementioned elements were almost totally retained by the head and the lungs immediately after exposure. After four days the lungs contained the largest percentage of these elements. The elements deposited in the head and bronchial tree were quickly eliminated via the gastrointestinal tract. The same avenue of elimination was presumably used by the nonciliated portion of the lungs, but at a slower rate. The small percentage absorbed into the body was primarily deposited in the skeleton after conditions of equilibrium had been established. Radioautographic studies indicate that the pulmonary site of deposition of these materials is in the bronchial passages and the alveolar structures. The materials are rapidly removed from the bronchial tree, presumably by ciliary action, and are slowly released from the alveoli. No accumulation of any of the radioelements was observed in either blood vessels or lymph nodes. (Auth) (RMF)

Radioautographs are given showing the pulmonary deposition of Pu aerosols.

<205>
Seaborg, G.T., University of California, Berkeley, CA. 1972

Plutonium Revisited. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 1-21), 552 p.

The achievements of the Radiobiology Laboratory of the University of Utah were reviewed. The initial assignment given the laboratory was to assess the role of plutonium as an industrial hazard. The history of plutonium research is given. (HP)

<206>
Semenov, D.I., and I.P. Tregubenko, Academy of Sciences of the USSR, Biophysics Laboratory, Sverdlovsk, USSR. 1958, January-February

The Action of Chelating Compounds on Tissue Storage and Excretion from the Living Organism of Radioyttrium, Radiocerium and Plutonium. Biochemistry, 23, 55-60.

Chelating agents, binding metal cations to form soluble, stable chelates under the conditions of the living organism, exert a pronounced effect on the radioisotope of yttrium, cerium and plutonium in the living organism. This effect is expressed in the averting of storage of the metals in the tissues and in the enhancement of the rate of excretion of the metal poisons into the urine. Experiments were carried out on white rats weighing 150-200 g. Yttrium 91 and Ce 144 were introduced in the form of chlorides (pH 2) into the caudal vein in proportions of 3 mCi/rat. Sodium salts of the chelating compounds were injected into the contralateral caudal vein in proportions of 2 x 10(E-5) mole (pH 7.3), 2 min. after injection of the radioisotope. Plutonium 239 was introduced intraperitoneally at a dose of 1 mCi/rat, in the form of the citric acid complex (pH 6). Sodium salts of the chelate were injected into the caudal vein 10 min. following the injection of Pu. A comparison of the effectiveness of the various chelating ligands assignable to the group of aminopolycarboxylic acid compounds, and also those of the phosphate group, points out substantial differences between the two groups, of both a quantitative and a qualitative nature. The ligands most effective in promoting the elimination of yttrium are uramyldiacetate and sodium ethylenediaminetetraacetate, while the most plutonium is hexametophosphate. The qualitative distinctions relate chiefly to the fact that the phosphates enhance storage of yttrium and plutonium in the tissues, although, in contrast to aminopolycarboxylic acid chelating agents, they sharply polycarboxylic acid chelating agents, they sharply reduce the accumulation of cerium in the skeleton. The data obtained attest to the fact that, aside from the stability of the compounds so formed, essential significance in determining the effectiveness of significance in determining the effectiveness of chelating agents may be assigned to the rate of the complexing process, and also to the physicochemical complexing process, and also to the physicochemical state of the metal in the blood stream and in the state of the metal in the blood stream and in the body fluids. The results cited and the conclusions drawn from them point to a possible role of biologands occurring naturally in the living organism (amino acids, citric acid, phosphates, etc.) in mineral metabolism. The high level of effectiveness observed for hexametophosphate with respect to cerium and plutonium is not susceptible to clinical utilization in view of the considerable toxicity of that preparation. At the same time, the effectiveness of uramyldiacetate, which exceeds that of ethylenediaminetetraacetate, and which lends itself to utilization for the treatment of heavy-metal poisoning and radioisotope poisoning, is deserving of special attention. (Auth) (FMM)

Table 3 shows Pu content in organs and excreta of rats on fourth day of experiment under action of various ligands.

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Sikov, M.R., and D.D. Mahburn, Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA. 1967, July

Effect of Age and Particle Size on Passage Time through the Gastrointestinal Tract of the Rat. BNWL-480; Part of Thompson, R.C. and Swezen, E. G. (Eds.), Annual Report for 1966, (P. 93-95), 207 p.

Plutonium oxide particles (CMD 0.13 u, 0.15 u, 1.8 u) were administered intragastrically to adult and 6-day-old rats. The animals were sacrificed at 1, 3, 7 and 21 days after administration and the retention and distribution in the gastrointestinal tract was determined. A poorly absorbed soluble tracer, Ru 106-Rh, was given intragastrically to another set of animals. Its distribution in the gastrointestinal tract was determined from 1/2 to 24 hr after administration. In the Pu study the smallest particle size tended to be excreted more completely than the other two, particularly in the newborn animals. A substantial fraction of all 3 particle size distributions was still present at 1 to 3 days following administration. While the overall passage times did not differ markedly for juvenile and adult animals, the shorter tract length of the neonate resulted in a substantially reduced rate of passage and a concomitant increase in the average time of contact with any given length of the tract. There was clear evidence for a longer retention of material in the stomach and in the ileum of the infant rat as compared to the adult. (RAF)

<208>
Sikov, M.R., and D.D. Mahlum, Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA. 1973

Influence of Age on the Late Effects of Monomeric Plutonium 239 in the Rat. CONF-730431, Part of Proceedings of the 21st Annual Symposium of the Radiation Research Society held in St. Louis, Missouri, April 2-May 3, 1973. Published in Radiation Research, 55(3), 514.

It has been shown that the metabolism as well as the acute and subacute toxicity of Pu 239 varies with age and physicochemical form. The late effects, including the eventual tumor responses were studied following exposure of rats to low levels of monomeric Pu 239 at several periods during life. Adult, weanling, newborn, and prenatal rats were exposed to monomeric Pu 239 by a single intravenous or intracardiac injection or by intravenous injection of the dam. Three dose levels which would give average radiation doses of approximately 7, 23, or 70 rads to the femur in the first 10 days after exposure, were used. Rats from each group were sacrificed at intervals for radioanalysis and autoradiography to establish the microdosimetry. The remaining animals and controls are being followed until death. At 18 months postinjection, the incidence of mortality and tumor development is greater among males than females. The highest incidence of osteosarcomas and chloroleukemias, the predominent tumor types, has been in the animals exposed as adults. Tumor incidence in the earlier-exposed groups is presently insufficient to indicate any differences in their sensitivities. A few hepatic tumors have appeared in rats exposed neonatally or prenatally but not in those exposed as weanlings or adults.
(Auth) (Complete Article)

<209>
Sikov, M.R., and D.D. Mahlum, Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA. 1972

Age-Dependence of Plutonium 239 Metabolism and Effect in the Rat. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 261-272), 552 p.

A number of studies were performed to evaluate the metabolism and effects of Pu 239 relative to animal age at time of administration. Included were experiments which have demonstrated differences in absorption and distribution following gavage at various ages. In other studies, the partition and microscopic deposition have been found to vary with the age at time of injection. The resulting effects are clearly influenced by metabolic differences as well as by the differences in age-related radiation sensitivity. In an analogous fashion, cross-placental transfer, distribution within the fetoplacental unit, and biological effect changed throughout gestation. These studies demonstrate that values obtained in the adult for calculation of permissible exposure limits to radionuclides may be inappropriate for immature individuals. (Auth)

Table 1 gives the distribution of Pu 239 in rats 24 hr after injection of monomer and polymer. Table 2 gives effect of age and physiochemical state on the partition of Pu 239 between liver and femur at 1 and 7 days after injection.

<210>
Smith, D.D., National Environmental Research Center, Monitoring Systems Research and Development Division, Las Vegas, NV. 1973, June

Status of the U.S. Environmental Protection Agency's Nevada Test Site Experimental Dairy Herd, January 1, 1969-December 31, 1970. NERC-LV-539-22, 62 p.

The U.S. Environmental Protection Agency's National Environmental Research Center, Las Vegas, maintans an experimental dairy herd in Area 15 of the Nevada Test Site. The status of this herd, for the period January 1, 1969 through December 31, 1970, is described. The report lists changes and improvements made on the facilities, presents herd and individual production and reproduction statistics, details health problems and treatments, and summarizes the metabolism, field and "ad hoc" research studies that involved the dairy herd. The dairy herd was utilized for studies which defined the critical metabolic pathways of selected radionuclides which might appear in the environment following a nuclear detonation. Each cow was selected on the basis of production, stage of gestation, breed and health. Specially designed metabolism stalls were used that provided continuous restraint but still allowed sufficient movement for comfort and easy access for milking and sample collection. The radionuclides were either administered orally, via gelatin capsules, or intravenously as an isotonic solution. Sampling of blood, urine, feces and milk took place every six hours until peak levels occurred. Metabolic studies were undertaken with the following radionuclides: iodine 131, wolfram 187, lead 203, thallium 202, wolfram 181, tritiated water, beryllium 7, rubidium 86, mercury 203 and iron 59. (RAF)

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<211>
Smith, H., and T.V. Chapman, Sunderland Polytechnic, School of Pharmacy, Sunderland, Durham, England; University of Dundee, Department of Medical Biophysics, Dundee, Scotland. 1969, August 9

Use of Citrate in Mobilizing Plutonium in Rat. Nature, 223, 642-643.

The use when citrate in the treatment of acute Pu poisoning is investigated in rats with a view of extrapolating the data to humans. Adult female Wistar rats, approximately 200 g body weight were each given an injection of 0.2 ml of a solution containing 1.7 x 10(E-3) ug of Pu 239 isotopically mixed with 0.4 x 10(E-5) ug of Pu 237 in 0.1 M citrate at pH 7. The animals were divided into groups and given an IP injection of 730 g citrate/kg of body weight either before, simultaneously with or after Pu injection. The maximum effectiveness was obtained when citrate was given simultaneously with the Pu and followed by a second injection after 90 min. Effectiveness fell off of citrate therapy was delayed, but it was of some value up to 24 hr after Pu. Citrate injected 30 min before Pu was of no value. The excretion data of Pu 237 in urine and feces showed preferential excretion in urine in the citrate-treated group in the initial 2 day period following citrate and excretion in both urine and feces occurred throughout the 24 days of the experiment. In a study on the influence of citrate (administered simultaneously with Pu) on the distribution of Pu 237 in the tissues, it was seen that, in a 3 hr period, there was more rapid transfer of Pu from the peritoneal cavity, an enhanced urinary excretion and a marked retention in liver in the citrate-treated group compared with the controls. There was, however, no difference in the amount of Pu transferred to bone. (FMM) (CIS)

Table 3 shows the influence of citrate on the distribution of Pu 237 in rat tissues.

<212>
Smith, V.H., General Electric Company, Hanford Laboratories, Biology Laboratory, Richland, WA. 1964, November 28

Prevention of Plutonium Deposition by Desferrioxamine-B. Nature, 204, 899-900; HW-SA-3590; 2 p.

Eight-mouth-old female rats were intravenoulsy injected with 2 uCi Pu 239(+4). One, 5, and 24 hr later they were treated with 0.5 mmol/kg of DTPA and DFAB (Desferrioxamine-B). Urine and fecal samples were taken. Five days later the animals were sacrificed. Statistically summarized results show that treatment with DFAB decreased bone deposition of Pu to about one-half the value obtained by DTPA and that the two agents given together produced a partially additive effect. The authors theorize that the enhanced effect of DFAB is probably due to its different in vivo distribution and the consequent tapping of Pu pools not available to DTPA. This is also suggested by the consistently lower bone deposition and higher fecal output of Pu in the DFAB treated animals. (RAF)

The effects of treatments on Pu content of liver, kidneys and femur and excreta five days after administration are given in tabular form.

<213>
Smith, V.H., Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA. 1972

Comparison of Efficiency of Removal of Plutonium, Calcium and Zinc from Rats by Calcium and Zinc DTPA. Radiation Research, 51, 540-541.

The relative radionuclide removal efficiency of calcium and zinc diethylenetriaminepentaacetic acid (Ca DTPA) was estimated when single treatments were given at one hour (prompt treatment), or multiple treatments were given starting at 6 days (delayed treatment) after the intravenous administration of Pu 238, Ce 144 and Zn 65 citrate (pH 4.6) to rats. The DTPA was administered intraperitoneally to groups of 6 to 8 rats at each treatment level. In the prompt treatment series the Zn DTPA levels varied from 0.005 to 2 mmol/kg with the optimum dose for removal of Pu or Ce from soft tissues and bone at about 1 to 1.5 mmol/kg, which agrees with results of a similar experiment with Ca DTPA. A greater fraction of the administered Pu was removed than Ce and below 0.5 mmol/kg, Ca DTPA removed more Pu than did similar doses of Zn DTPA. There was no optimum dose for removal of Zn 65 which was exchanged in direct proportion to the chelate dose. Twelve treatments at DTPA levels of 0.001 to 1 mmol/kg were given over 42 days in the delayed treatment series. At lower doses, 0.001 and 0.01 mmol/kg, the Ca DTPA appeared more efficient at removing Pu and Ce from soft tissues while Zn DTPA caused more removal from bone, however, at about 0.1 mmol/kg these differences disappeared. The effectiveness of both salts were essentially equivalent in causing removal of the Zn 65. (Auth) (Complete Article)

<214>
Smith, V.H., Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1974, February

The Biological Disposition of Einsteinium Nitrate Es(NO3)3 in Rats After Intravenous, Intramsucular and Subcutaneous Administration. CONF-730907 (Part 1); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 725-730), 1475 p.

Adult, female, Wistar-strain rats were injected with 4.76 uCi Es as the nitrate in 0.20 cc pH 2.0 solution (90% ultrafilterable) intravenously (IV), intramuscularly (IM) and subcutaneously (SC). Regardless of the injection route, Es(NO3)3 was retained preponderantly in the skeleton up to 24 days after administration. The liver burden decreased from 26% of the inital Es administered IV at 4 hours to 14% at 1 day and less than 2% at 24 days. The skeletal content increased to about 70% on day 7 and decreased to about 56% by day 24. The liver and skeletal retention at 24 days from the SC and IM injections was slightly less than from the IV route. Injection site retention was greater for the SC route, 16%, than for the IM route, 8%. The popliteal lymph nodes adjacent to the IM injection site retained about 0.7% of the injected dose/g compared to about 0.1 that value for the other lymph nodes and routes. Kidney concentrations at 24 days were higher from the IM and SC routes, 0.56%/g, and 0.43%/g, than from the IV route, 0.33%/g and all were higher than the liver concentrations of 0.11-0.16%/g wet weight. In common with other actinides, Es

<214> CONT.
was concentrated more in the vertebrae and sternum than in other bones. Excretion was higher initially in the urine, but by the 5th day more was being excreted in the feces. Skin absorption was very high, about 4% of the available Es (2.5 uCi/cm2, pH 2 nitrate solution) being absorbed in 30 min. (Auth)

Figure 2 shows Es 253 distribution in rats 24 days following the injection of Es(NO3)3 by various routes. Table 1 shows Es 253 concentration in tissues after administration of 4.76 uCi Es(NO3)3 to rats.

<215>
Smith, V.H., J.L. Palotay, B.J. McClanahan, H.A. Ragan, and W.J. Clarke, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1966, January 3

Plutonium 238 SNAP Fuel Ingestion by Miniature Swine. BNWL-182, Part of Thompson, R.C., Summary Technical Report, SNPO and SNAP Biological Studies, (p. 10-14), 16 p.

A 49.2 kg Hanford miniature pig was fed a massive dose (approximately 1 Ci) of Pu 238 SNAP fuel particle. Total urine and feces collections and periodic blood samples were obtained for 14 days following PuO2 feeding. The pig was then sacrificed and tissues analyzed. There was prolonged and extensive holdup of the particles in the intestinal tract. Slightly less than half of the ingested activity was excreted during the first 6 days. The remaining activity was, however, almost totally excreted during the next 5 days. The total Pu 238 recovered in the urine and in the tissues at sacrifice amounted to 2 x 10(E-7) times the amount fed. Over 98% of this absorbed Pu was recovered from lymph nodes. The relatively enormous dose of 1 Ci resulted in no grossly evident damage to the gastrointestinal tract, and to negligible deposition in the probably most critical organs, bone, and liver. Any conceivable hazard from ingestion of this material would certainly be far outweighed by the accompanying hazard of inhalation. (PMM)

Table 2 shows Pu 238 content of tissues of pig 14 days postingestion.

<216>
Snider, R.S., Not given. 1948

The Skin. Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 4. McGraw Hill Book Company, Inc., New York, New York, (p. 32-69), 808 p.

Histopathological studies on the skin were made after application of the following irradiations from an external source: (1) beta rays to mice (2,500 and 5,000 rep), rats (625, 50, 5, and 0.5 rep, daily dose), and rabbits (2,500, 5,000, and 12,000 rep locally applied); (2) x rays to rats (600 R), rabbits (800, 100, 50, 25, 12 R, and 6 R); (3) gamma rays to guinea pigs (8.8 R, daily dose), (4) fast neutrons to rabbits (117 n), mice (117, 96, and 65 n); (5) slow neutrons to mice (400 arbitrary units). Histopathological studies on the skin were made after application of the following irradiations from internal sources: (1) alpha rays to mice from intramuscular injections of 0.1 uCi/g of plutonium and to mice from intraperitoneal injections of 1.0 uCi/g of radium; (2) beta rays to rats from intravenous injections of 2.0 uCi/g of yttrium 91 and to rats from intraperitoneal injections of 0.6 and 0.25 uCi/g of strontium 89. Striking changes were not seen in any of the above preparations except in the animals treated with external beta rays. This fact is interpreted as being due to the higher dose used rather than to any action on the skin which is specific for external beta rays. In general, these skin changes were similar to those described by previous workers using relatively large doses of x rays. (Auth)

Several histological sections are shown.

<217>
Snipes, M.B., and A.L. Brooks, Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1974, December

An Analysis of Dosimetry and Cellular Risk for Plutonium Particles in the Lung. LF-49, Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 29-36), 384 p.

Current standards use absorbed radiation dose for uniformly dispersed radionuclide as the basis for defining risk and a maximum permissible lung burden (MPLB). Present data are insufficient to prove that a uniform dispersion of plutonium in lung tissue is more or less hazardous than a particulate form where discrete centers of alpha activity yield higher radiation doses to their surroundings than would occur for uniformly dispersed radionuclides. Tissue adjacent to and irradiated by these particles may represent only a small fraction of the total lung. The implications of a higher dose and dose rate to these small tissue volumes necessitates the determination of the relative risk to lung tissue for this pattern of radionuclide distribution. The paper discusses biological and physical factors associated with particle dosimetry in lung tissue. Data are presented, along with theoretical examples, which suggest that particulate forms of plutonium in lung tissue are less hazardous than a uniformly dispersed lung burden. A most important factor in lung dosimetry for particulate forms of plutonium is cell turnover time. Cells with short turonver times are at greatest risk from larger plutonium particles, whereas cells with long turnover times are at greatest risk from small plutonium particles. Analysis indicates that, using 200 rads as a lethal dose to individual cells, particles of Pu 238 PuO2 from 0.1 um to 0.3 um represent the maximum size particles which deliver a sublethal dose to some portion of the dose sphere around the particle during the time period 10 to 365 days after exposure. Comparable numbers for Pu 239 PuO2 are 0.6 um to 2 um, respectively. Particles large enough to produce a radiation dose to surrounding cells greater than 200 rads during the critical time period yield cell death with a subsequent decrease in cell risk, or potential for carcinogenesis. (Auth)

<218>
Spiers, F.W., International Atomic Energy Agency, Vienna, Austria. 1971

Biophysical Basis for Radiation Haematology. STI/DOC/10; Technical Reports Series No. 123; Part of Manual on Radiation Haematology, Chapter 3, (p. 45-69).

The six parts of this technical report review

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the following areas: physical characteristics of ionizing radiations (charged particles, x-rays, gamma rays, neutrons, particle tracks); units of radiation dose (absorbed dose, radiation exposure, absorbed dose and LET, RBE); location of relevant hematological tissues; physical description of trabecular bone (distribution of active marrow, bone mensuration, a new method for specifying trabecular and marrow-cavity dimensions, path length distributions); determination of mean dose to active marrow (single and multiple cavity calculations, experimental data of mean marrow dose and some results for X-rays and beta particles); alpha particle and neutron irradiation (volume and surface distributed isotopes, alpha particle dose from volume and surface distributed isotopes, Pu 293 dosimetry in rabbit bone and bone marrow and bone marrow dose from neutron irradiation). Experimental data suggest that Pu 239 deposits occur on all bone surfaces with the greater concentration on endosteal surfaces. Plutonium was also found in the bone marrow itself appearing both as a diffuse distribution of single tracks and as discrete small aggregates (stars). (RAF)

<219>
Stather, J.W., and S. Howden, National Radiological Protection Board, Harwell, England. 1975, January

The Effect of Chemical Form on the Clearance of Plutonium 239 from the Respiratory System of the Rat. Health Physics, 28, 29-39.

This study has investigated the effect of chemical form on the tissue distribution and excretion of plutonium following its deposition in the respiratory system of the rat. Solutions of various chemical forms of plutonium (nitrate, citrate, oxalate, dioxide, DTPA complex) have been administered to rats by intubation into the nasopharyngeal, tracheobronchial or pulmonary regions of the respiratory tract. The injection volume was less than 3 ul and the activity administered (2-3 nCi/kg) was comparable to a few maximum permissible body burdens of plutonium in man. The absorption of both plutonium nitrate and citrate from the pulmonary region was approximately four times greater than the absoprtion from either the tracheobronchial or nasopharyngeal regions. However, of the plutonium deposited in any of the three regions, the relative proportion that is translocated to other tissues was greater following administration as citrate than nitrate (approximately in the ratio of 1.6:1). The absorption of various chemical forms of plutonium from the pulmonary region was in general agreement with the conclusions of the ICRP Task Group on Lung Dynamics. About 13% of activity entering the blood during the first week after administration of plutonium nitrate or citrate was retained in the liver at 7 days implying that plutonium was circulating in the blood in a "monomeric" form. The cumulative excretion of plutonium in the urine in the same period was equivalent to about 4% of the total activity deposited in tissues from the blood. The experimental results suggest that this value could be used for calculating the total tissue deposit from urinary excretion measurements. (Auth)

<220>
Stevens, W., D.R. Atherton, B.J. Stover, and F.W. Bruenger, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1973, July

Comparison of the Intracellular Distribution of Plutonium 239, Americium 241 and Californium 249 in Livers After Intravenous Administration. CONF-730431; Part of Proceedings of the 21st Annual Symposium of the Radiation Research Society held in St. Louis, Missouri, April 29-May 3, 1973. Published in Radiation Research, 55(3), 513.

The intracellular distribution in livers of beagles injected intravenously with either Pu(+4) 239, Am(+3) 241 or Cf(+3) 249 in 0.08 M citrate, pH 3.5 was studied serially. Liver homogenates were fractionated by differential centrifugation. A mitochondrial fraction was obtained by centrifugation at 60,000 g min, a lysosomal fraction at 8 x 10(E+5) g min and a cytosol at 6 x 10(E+6) g min. Initially all three nuclides were found in the cytosol and mostly associated with ferritin. Considerably higher concentrations of americium and californium than plutonium remained in the cytosol at progressively longer times after administration. The order of the rate of removal of nuclide from the cytosol was Pu>>Cf>Am. As the nuclide was removed from cytosol it became associated with subcellular organelles. No constant relationship was observed between concentration of nuclide and mitochondrial or lysosomal marker. The ratio of nuclide to lysosomal marker was consistently higher in the mitochondrial fraction than in the lysosomal fraction. However, significant contamination of the mitochondrial fraction with lysosomes has not been demonstrated using electron microscopy. It is concluded from this study that mitochondria and lysosomes and possibly other organelles are involved with nuclide binding in canine liver cells. (Auth) (Complete Article)

<221>
Stevens, W., and D.L. Berliner, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1964

Serum Transaminase Levels in Beagle Dogs Burdened with Plutonium 239. Radiation Research, 23, 420-429.

Serum glutamic oxaloacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) were measured in beagle dogs injected intravenously with Pu 239 in dose levels ranging from 0.016 uCi/kg to 2.9 uCi/kg. A significant difference in SGPT between males and females of the control group was demonstrated. There was no significant difference between the SGOT values of the males and females. There is a correlation between the injected dose of Pu 239 and the per cent of SGOT and SGPT measurements that are elevated. The dogs injected with the highest doses of Pu 239 showed elevated transaminase values over the period of the experiment. The increase in SGOT and SGPT in plutonium-burdened dogs is attributed to the significant deposition of Pu 239 in the livers of these animals. (Auth)

<222>
Stevens, W., F.W. Bruenger, and B.J. Stover, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1967, March 31

In Vivo Studies on the Interactions of Plutonium(+4) with Blood Constituents. COO-119-236; Part of Dougherty, T.F., Research

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<222> CONT.
in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 173-190), 268 p.; Radiation Research, 33, 490-500.

The distribution of Pu(+4) in blood plasma of beagles was determined as a function of time after injection of Pu(+4). The animals were injected intravenously with amounts of Pu(+4) ranging from 0.9 to 2.7 uCi of Pu 239/kg in 0.08m citrate, pH 3.5. The plasma was subjected to gelfiltration on G-100, G-200 columns. Significant amounts of Pu(+4) were found in the region of low molecular weight proteins as well as in the molecular weight range of small molecules and ions. The amount of Pu(+4) bound to protein increased during the first few hours after injection and reached a maximum at about 7 hours. From that time on it decreased steadily. Concommitantly the Pu(+4) found in the region of low molecular weight compounds decreased continuously from 5 minutes to 30 days. The decrease in the amount of Pu(+4) in the region of low molecular weight compounds occurred more rapidly than did the decrease in Pu(+4) associated with low molecular weight proteins. The proteins that bound Pu(+4) were identified as transferrin and albumin. These protein-Pu(+4) complexes were separated by ion-exchange chromatography. Their identity was confirmed by electrophoresis as well as Fe ^{59} labeling. The amount of Pu(+4) bound by transferrin greatly exceeded the amount bound by albumin. (Auth)

<223>
Stevens, W., C.J. Nabors, Jr., and D.L. Berliner, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1966, March 31

A Comparision of Serum Transaminase Levels and Other Serum Constituents in Dogs Burdened with Plutonium 239, Thorium 228, Radium 228, and Radium 226. COO-119-234, Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 94-119), 326 p.

Beagle dogs, 15-16 months old were injected intravenously with different dose levels of the radionuclides Pu 239, Th 228, Ra 228 and Ra 226, in a solution of citric acid-sodium citrate buffer pH 3.5. The injection of these bone seeking radionuclides produced as the major biological endpoint osteogenic sarcomas. The incidence of these tumors increased as the injected dose of radionuclides was increased. In Th 228 1.0 level dose, 100% of the dogs had osteosarcomas. In all radionuclide-injected groups the increased incidence of osteogenic sarcomas was accompanied by increases in the number of serum alkaline phosphotase measurements that were elevated. Pu injected dogs had the greatest increase in elevated alkaline phosphatase measurements followed by Th 228, then Ra 228 and finally by Ra 226. These data indicate that in the case of the four radionuclides studied one of the determining factors for the changes in the blood chemistry values is the distribution of the nuclide in the animal. The skeletal deposition for Th 228 is about 80% of the retained dose; and for Pu 239 it is about 70% of the retained dose. The remaining amounts are deposited in the soft tissues. In soft tissues thorium is more generally distributed than plutonium which is mainly in the liver. These two nuclides had the greatest effect on serum albumin and globulins. Plutonium produced significant elevations in serum glutamic-pyruvic transaminase (SGPT) and serum glutamic-oxaloacetic transaminase (SGOT), whereas thorium produced only small increases at low dose levels. (FMM)

This article is identical to the journal article. Appearing in Annals of the New York Academy of Sciences, 145(1), 817-829, 1967, with the exception of Table 2 which differs in its values.

<224>
Stevens, W., C.J. Nabors, and D.L. Berliner, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1966

Relationship Between Serum Alkaline Phosphatase and Osteosarcoma in Plutonium 239 Burdened Dogs. CONF-660212, Part of Proceedings of the 14th Annual Symposium of the Radiation Research Society held in Coronado, California, February 13-16, 1966. Published in Radiation Research, 27, 549.

The relationship between serum alkaline phosphatase and bone disease was first described in 1923. It was shown that serum alkaline phosphatase increases in bone diseases such as osteogenic sarcoma. Serum alkaline phosphatase was measured in a group of purebred beagle dogs injected with doses of plutonium 239 ranging from 0.016 uCi Pu 239/kg to 3.0 uCi Pu 239/kg. Alkaline phosphatase was measured using standard colormetric procedures and expressed in Bodansky units. The control group consist of noninjected dogs raised and maintained in our colony under the same conditions as the dogs injected with plutonium. The mean and standard deviation for the normal female was 4.46 plus or minus 2.52 units/100 ml and for the normal males 4.56 plus or minus 2.52 units/100 ml. Values that exceeded the 90% confidence limits were considered elevated. Definitive diagnosis of osteosarcomas was obtained by standard post-mortem procedures as well as radiographic diagnosis in living dogs. A positive correlation between elevated pre-terminal alkaline phosphatase measurements and incidence of osteosarcomas was found. Eighty-six per cent of the dogs originally injected with plutonium in this study are now dead. Of these dead dogs, 78% had osteosarcomas and 88% of these showed elevated alkaline phosphatase levels. Alkaline phosphatase levels were also measured in control animals bearing no radioactivity. In this group, 19% of the animals showed elevated alkaline phosphatase levels. These findings suggest that this measurement along with other data can be used to aid in early recognition of osteosarcomas before they become clinically observable. (Auth)

<225>
Stevens, W., C.J. Nabors, and D.L. Berliner, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1967, October 18

A Comparison of Serum Transaminase Levels and Other Serum Constituents in Dogs Burdened with Plutonium 239, Thorium 228, Radium 228 and Radium 226. Annals of the New York Academy of Sciences, 145(1), 817-829.

Young beagle dogs were given a single intravenous injection of Pu 239, Th 228, Ra 226 and Ra 228 in a citrate buffer (pH 3.5) at different dose levels. Blood samples were

<225>

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<225> CONT.
taken after 1, 2 and 6 months and at yearly intervals following injection. The injection of these bone-seeking radionuclides produced as the major biological end point osteogenic sarcomas. The incidence of the tumors increased as the dose of radionuclide increased. The increased incidence of osteogenic sarcomas was accompanied by elevated serum alkaline phosphatase levels. Plutonium injected dogs had the greatest increase in serum alkaline phosphatase measurements followed by Th 228, Ra 228, and Ra 226. Serum glutamic pyruvic transaminase (SGPT) levels in dogs is specific for liver damage and necrosis. Significant increases in SGPT measurements were noted in Pu animals. Elevation of SGPT was also produced by Ra 226 but was not as marked as with Pu 239. Radiothorium which is chemically similar and has a similar distribution pattern did not produce the same effect on SGPT as Pu (Pu liver retention is 10-20 times higher than the retention). Ra 228 had very little effect on SGPT at any dose level. The effects of the 4 radionuclides on albumin and globulin in serum were thought to be related to their distribution in the animal. Radium 226 and Ra 228 which deposit almost exclusively in the skeleton had little effect on serum proteins. Plutonium and Th which deposit in soft tissues, primarily liver, spleen, and kidney for Th, and liver for Pu, produced marked hypoalbuminemia and hyperglobulinemia. No significant changes were observed in total proteins for any of the nuclide burdened groups of animals. Results indicate that one of the determining factors in changes of blood chemistry values is the distribution of nuclide in the animal. (RAF)

Tables are given of ∇ alkaline phophatase measurements elevated and incidence of osteosarcoma. The ∇ SGPT and SGOT measurements elevated in Pu 239, Th 228, Ra 226 and Ra 228 burdened dogs and changes in albumin/globulin ratios are shown in graphic form. This article is identical to the report, COO-119-234, (p. 94-119), 1966, with the exception of Table 2 which differs in its values.

<226>
Stevens, W., R.J. Stover, F.W. Bruenger, and G.N. Taylor, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1969

Some Observations of the Deposition of Americium 241 in the Thyroid Gland of the Beagle. Radiation Research, 39, 201-206.

The distribution of Am 241 in the thyroid glands of three dogs after intravenous injection was studied. Dog 1, weighing 10.7 kg, received 2.78 uCi of Am 241/kg and was sacrificed 22 days after injection. Dogs 2 and 3 weighing 11.05 kg and 10.5 kg received 4.45 uCi of Am 241/kg and were sacrificed at 7 and 8 days after injection, respectively. The thyroid glands were removed, frozen immediately in liquid N2, and counted. Later the thyroid tissue was homogenized and separated into fractions by differential centrifugation. Eight-five to ninety per cent of the Am 241 was found with the crude fibrous residue. Combining this fibrous material with cell nuclei and membranes accounted for more than 90% of the total activity found in the thyroid. Only very small quantities were found with microsomes, mitochondria, and in the 105,000 x g supernatant. It is concluded that Am 241 is selectively bound by the connective tissue elements of the thyroid. The concentration of Am 241 in thyroid connective tissue was found to be 337 times that of a sample of subcutaneous loose connective tissue and 4 times that of connective tissue derived from the liver. (Auth) (FMM)

Table 2 shows the average concentration of Am 241 in selected organs (liver, bone thyroid) of 3 beagle dogs. Table 5 shows concentrations of Am 241 in connective tissue residues derived from organ homogenates (liver, spleen, kidney, thyroid and adrenal).

<227>
Stover, B.J., D.R. Atherton, F.W. Bruenger, and W. Stevens, University of North Carolina, Chapel Hill, NC, University of Utah, Salt Lake City, UT. 1972

Comparison of Skeletal and Hepatic Dose Rates from Plutonium 239 in the Beagle As a Function of Dose Level. Radiation Research, 51, 541.

The total skeletal retention was measured in several dogs that were injected intravenously with 0.005 uCi 239 Pu(+4)/kg in 0.08 M citrate buffer, pH 3.5. The beagles were young adults at the time of injection, and they were sacrificed sufficiently long after injection that the rate of remodelling of bone surfaces, a process which removes Pu 239 deposited on bone surfaces, had decreased significantly. These results are combined with previous data on early deposition and retention in the skeleton, and early and long term data on retention in the humerus and third lumbar vertebra, to obtain a set of skeletal retention equations applicable to seven dose levels. Using these equations and similar ones calculated previously for hepatic retention, the cumulative rad doses to the skeleton and liver are compared as a function of dose level. (Auth)

<228>
Stover, B.J., D.R. Atherton, F.W. Bruenger, and C.N. Taylor, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1966

Plutonium 239 in Liver, Spleen, and Kidneys of the Beagle. Radiation Research, 27, 548-549.

Following a single intravenous injection of 0.30 uCi Pu 239/g in beagle dogs, both amount and concentration of Pu 239 in liver, spleen, and kidneys were found to decrease with time from 40 to 1950 days. The rates of decrease are significant but sufficiently slow that either descending exponentials or straight lines can be fit for this time interval. When compared with the fitted lines, results from dogs given 0.01 uCi Pu 239/g and living 1066 to 1724 days and those given 0.095 uCi Pu 239/g and living 1617 to 3185 days showed a dose level effect on retention in the liver. There was no readily apparent dose level effect on retention in the spleen and kidneys. Possible relationship of gross and microscopic changes in the liver and the observed dose level effect will be discussed. (AUTH) (Complete Text)

<229>
Stover, B.J., and D.R. Atherton, 1974

Kinetics of the Skeletal Retention of Plutonium 239(+4). Radiation Research, 60, 525-535.

A kinetic analysis of the observed skeletal retention of Pu 239(+4) in the beagle is

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<229> CONT.
presented. Since skeletal retention is directly related to bone-remodelling processes, the analysis applies only to beagles that are injected in young adulthood at dose levels less than 0.095 uCi Pu 239(+4)/kg. At these dose levels the effect of irradiation on bone remodelling and, hence, skeletal retention, is less than the variation between animals. The kinetics are derived from these macro and micro observations: (1) The initial deposition and the rate of decrease in retention are both higher in bones that have a relatively greater amount of trabecular bone. One ulna, which has a relatively greater amount of cortical bone, was analyzed from each of 40 beagles at dose levels from 0.00064 to 0.095 uCi/kg and at times from 35 to 4549 days after injection. Retention of Pu 239(+4) in the ulna was approximately constant over 12.5 yr, which is in contrast with the retention in the humerus and in the third lumbar vertebra. In these bones retention decreased during the first several years and then approached approximately constant values. Also, comparison of the initial concentrations shows that that of the ulna was only about 25% that of the other two bones. (2) W.S.S. Jee has shown that Pu 239(+4) deposits initially on osseous surfaces. When through osteoblastic activity surface deposits are buried and Pu 239 appears diffusely in new bone. Through osteoclastic activity surface deposits are resorbed and Pu 239 appears in osteoclasts. Later Pu 239 appears in macrophages, which in the final step disappear from bone. The macro and microevents are consistent in time. The kinetic model that is derived could lead to the identification of a more meaningful dose rate parameter and also could provide a basis for estimating bone remodelling rates in the young adult beagle. (Auth)

The retention of Pu 239 in the ulna, humerus, and third lumbar vertebrae at 35 days-12.5 years after injection is given in tabular and graphic form.

<230>
Stover, B.J., D.R. Atherton, F.W. Bruenger, and D.S. Bister, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1967, March 31

Plutonium 239 in Liver, Spleen, and Kidneys of the Beagle. COO-119-236; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 164-172), 268 p.

The initial deposition of Pu 239 in the liver of dogs is independent of injected dose over the range 0.096 to 2.8 uCi/kg. The long term hepatic retention depends on the injected dose as well as time. The rate of decrease of hepatic retention is proportional to the early radiation dose rate to the liver. A similar effect was not observed in renal and splenic retention of Pu 239. The radiation dose rate to these tissues is considerably less than that to the liver. (Auth)

Table 1 shows apparent half-periods (in days) for Pu 239 in beagle tissues (0.30 uCi Pu 239/kg injected). Equations were calculated from the data relating the percent in the tissue to the time since injection.

<231>
Stover, B.J., F.W. Bruenger, W. Stevens, D.R. Atherton, and G.N. Taylor, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

The Effect of the Physical-Chemical State of Plutonium on its Early Retention in Plasma and Selected Soft Tissues of Beagles. Radiation Research, 51, 539.

The early retention of Pu 239(+4) in plasma, kidney, spleen and other selected soft tissues was studied in beagles after injection of the strictly monomeric Pu-transferrin complex (Pu-Tf), non polymeric Pu(+4) in citrate buffer of pH 3.5 (Pu-M), and largely polymeric Pu(+4) in citrate buffer of pH 6 (Pu-P). Plasma concentrations of plutonium were calculated as semi-log functions of time after injection. Pu-Tf was removed from the circulation at a rate slower than Pu-M, whereas, Pu-P initially left the blood at a very rapid rate. At 15' after injection equivalent to 87%, 64% and <2% of the three forms of plutonium were circulating, plasma, 100% of Pu-Tf and a large fraction of Pu-M was protein bound. No protein binding of Pu-P was seen. At two weeks after injection, concentrations of plutonium in most soft tissues were quite similar for Pu-Tf and Pu-M. Kidney retention was decreased by a factor of 10, whereas spleen retention was increased by a factor of >30 in the Pu-P injected animal. The concentration of Pu-P in the spleen was 1.6 times greater than the concentration in the liver. Following differential centrifugation of tissue homogenates from Pu-P injected animals the percentage of plutonium in the soluble fraction is greatly reduced in spleen, but not in similar fractions of kidney when compared to Pu-Tf and Pu-M injected dogs. Most of the nuclide in the kidney was bound to the fraction rich in mitochondria. In the case of Pu-P, a large concentration of plutonium also was found in the nuclear fraction of spleen homogenates. The concentration of plutonium in thyroid, adrenal, pituitary, dura mater, loose connective tissue and other soft tissues will be compared. Autoradiographs of selected soft tissues will be shown. (Auth) (Complete Article)

<232>
Stover, B.J., W. Stevens, and F.W. Bruenger, University of North Carolina, Department of Pharmacology, Chapel Hill, NC, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

Chemical Associations of Plutonium 239(+4) and Americium 241(+3) in Blood, Liver and Thyroid. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 129-140), 552 p.

Plutonium, as Pu 239(+4) in 0.08 M citrate buffer of pH 3.5, was given by intravenous injection to young adult beagles. Following injection the concentration of plutonium in blood decreased slowly, since a large but variable fraction of the plutonium formed a complex with transferrin, the iron transport protein. The Pu(+4)-transferrin complex was sufficiently stable to be separated from other serum constituents. The formation of Pu(+4)-transferrin was blocked by Fe(+3) and Pu(+4) was displaced from the complex by Fe(+3). The Pu(+4)-transferrin association was reversed by citrate at pH 7.5. Some plutonium deposits in most tissues, but the principal sites of depostion are in the skeleton and the liver. Hepatic retention of plutonium decreased slowly with time at all

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dose levels, but the rate of decrease was greater at higher levels where there is marked destruction of hepatic cells. At the subcellular level in the liver, significant concentrations of plutonium were observed in nuclear, mitochondrial, and microsomal fractions, in the cytosol, and also in connective tissue. In the cytosol most of the plutonium occurred in association with ferritin, the iron storage protein. It was also found in association with lipofuscin and with an unidentified material of molecular weight of about 1500. The association of plutonium with ferritin is highly stable. The probable mechanism by which Pu(+4)-ferritin is eliminated from the liver is through death of the hepatic cell followed by phagocytosis by RE cells and subsequent localization in the portal regions. In contrast, americium, Am 241(+3), injected in the same buffer, was cleared rapidly from the blood. Am(III) does form complexes in the blood with both transferrin and albumin, but they are less stable under physiological conditions than the complexes of plutonium. The skeleton and liver are also the principal deposition sites for americium, and the rate of decrease of hepatic retention increases with increasing dose level because of destruction of cells. Significant concentrations of americium were found in the several subcellular fractions of the liver. In comparison with plutonium relatively more americium was found in the hepatic cytosol, in association with ferritin, lipofuscin, and a material of low molecular weight. The relative amount of americium found in the low molecular weight fraction was greater than in the case of plutonium. Significant concentrations of americium were found in the connective tissue of the thyroid. (Auth)

Table 1 gives relative concentrations of Am 241 and Pu 239 liver fractions one week after injection.

<233>
Stover, B.J., and C.N. Stover, Jr., University of North Carolina, Department of Pharmacology, Chapel Hill, NC; University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

The Laboratory for Radiobiology at the University of Utah. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 29-46), 552 p.

The toxicological effects of Pu were investigated early in Chicago and osteosarcomas and group skeletal damage in mice were confirmed. As metabolic information on Pu accumulated, it became evident the distribution pattern of the radionuclide was affected by chemical form, administration route, animal species exposed and age at exposure. The developement of Radiobiology Laboratory at the University of Utah is described. (HP)

<234>
Stover, C.N., Jr., University of Utah, College of Medicine, Radiobiology Division, Salt Lake City, UT. 1959

Annual Progress Report, March 31, 1959. CCO-218; 224 p.

Progress is reported on the studies in dogs injected with Ra 226, Th 228, Ra 228, Sr 90 or Pu 239. Seven papers have been abstracted separately for inclusion in the data base. These include studies on histopathologic bone changes in bones containing Pu, determination of Pu 239 content of bone tissue, radiation induced osteogenic sarcoma in dogs and the biochemistry report. (FMM)

<235>
Strel'tsova, V.N., and Yu.I. Moskalev, Not given. 1957

Radioactive Isotopes as Cancerogenic Agents. Meditsinskaya Radiologiya, 2(5), 39-51.(Russian)

Tumors of various tissues appear in animals which are affected by radioactive substances, such as osteosarcoma, adenoma and cancer of the mammary gland, leukemia, adenoma of hypophysis, of suprarenal glands, of thymus and thyroid glands, sarcoma of lympa nodes, of subcutaneous tissue, of the ovaries, adenoma and cancer of the liver, cancers of the lung, of the ovaries, the stomach, the small and large intestines or of the skin. Isotopes which are usually located in the skeleton usually cause osteosarcomas, those in the skeleton and in the liver--osteosarcomas, tumor of the liver or of the endocrine glands. Isotopes which are distributed evenly all over the body cause various tumors of the soft tissues. The incidence of osteosarcomas depends on the quantity of the radioactive substance which was introduced and on the effective period of the actual fission of the isotope. The higher the activity and the effective period of the 'actual' fission--the more the percentage of development of the tumors. The optimal osteosarcomagenic dose of absorbed energy for irradiators equals to 10-20 krep, the minimal dose being 2-3 krep. When dealing with isotopes which are rapidly and completely resorbed from a depot, the character and the type of tumor reaction does not depend on the method of their introduction. On the contrary, in case of isotopes which are poorly resorbed the tumor reaction not only depends but frequently is determined by the method of introduction of the isotope. Distribution of the isotope has no qualitative effect on the appearance of the tumors of the mammary glands and on leukemias. The incidence of leukemias, induced by radioactive isotopes ranges from 3 to 10 percent. (Translator)

Tables are given of overall characteristic distribution of radionuclides in skeleton, liver, muscle, kidneys, spleen, lymph nodes and bone marrow.

<236>
Sullivan, M.F., and W.F. Smith, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1974, August

Removal of Intramuscularly Injected Plutonium 238-Nitrate from the Rat by Continuous Infusion of Chelating Agents. PNWL-1850 (Part 1), Part of Thompson, R.C., et al, Annual Report for 1973, (p. 112-114), 162 p.

Chelating agents, Ca EDTA, Ca DTPA and Zn DTPA were administered by continuous infusion to rats injected intramuscularly with Pu 238 $(NO3)4$. The appropriate amount of chelating agent in 7.4 ml of pH 7.2 solution was delivered over every 24 hr. period by infusion pumps, via catheters implanted in the peritoneal cavity or under the skin in the nuchal region of the rats. It was shown that continuous infusion of EDTA or DTPA showed little therapeutic advantage over

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<236> CONT.
rapidly administered, single, daily treatments. Due to the greater toxicity of continuously infused Ca DTPA, procedures sustaining that agent in the system overly long should be considered potentially hazardous. (Auth) (FMM)

<237>
Sullivan, M.F., and R.C. Thompson, General Electric Company, Hanford Laboratories, Biology Operation, Richland, WA. 1957, September 28

Absence of Lethal Radiation Effects Following Massive Oral Administration of Plutonium. Nature, 180(4587), 651-652.

Plutonium 239 was administered to seventy-five rats, by stomach tube, as a hydrated polymer suspended in a nitrate solution at pH 2. From the results it was seen that death did not occur from a dose less than 88 mCi/kg, and that all mortalities resulting from plutonium ingestion occurred within 24 hr. Rats surviving the plutonium feedings were observed for at least six months. Blood counts and body-weight changes did not vary significantly from those of control animals. The oral plutonium dose of 88 mCi/kgm which resulted in only 25 percent mortality can be calculated to have delivered at the surface of the contents of the small intestine a radiation dose of approximately 650,000 rem. Since this very large dose resulted in none of the symptoms characteristic of the intestinal radiation syndrome, it may be concluded that alpha-radiation originating within the contents of the intestine is largely ineffective in causing acute damage to the intestinal wall. It would appear that for all practical purposes of hazard evaluation, alpha-emitting radioisotopes contained within the gastrointestinal tract may be ignored in calculating maximum permissible concentrations. In contrast to the results with plutonium 239, similar studies involving the oral administration of yttrium 91 indicate that beta particles originating within the contents of the gastrointestinal tract are approximately as effective as external x irradiation in eliciting all of the symptoms of the intestinal radiation syndrome. (FMM)

<238>
Szot, Z.Z., and D.M. Taylor, Institute of Cancer Research, Royal Cancer Hospital, Department of Physics, London, England. 1962

The Effect of Treatment with Diethylenetriaminepentaacetic Acid on the Distribution of Plutonium 239 Within the Femur of the Rat. Radiation Research, 16(4), 583.

The distribution of intravenously administered Pu 239 in the proximal, shaft and distal regions of the femur has been studied in young growing rats treated with diethylenetriaminepentaacetic acid (DTPA) at various times after the administration of plutonium. In untreated animals the highest concentrations of Pu 239 are found in the distal (epiphyseal) region of the bone, and the lowest concentration occurs in the shaft region. Intraperitoneal injections of DTPA, 1.5 mM + 1.0 mM Ca Cl2/kg body weight, within 60 seconds of Pu 239 administration results in a fairly uniform reduction of the amount of Pu 239 retained in the three regions of the bone at 28 days. When the treatment is commenced 1 hour after plutonium administration there is a greater removal of Pu 239 from the distal region than from the other two areas. A similar, but less pronounced, effect is seen when treatment is started 7 days after Pu 239 injection, but if the start of treatment is delayed until 17 days this effect is not seen. The possible biological significance of these observations will be discussed. (Auth) (Complete Article)

<239>
Takebe, H., Osaka University, Osaka, Japan. 1972, February

Effects of Low Dose of Radiation on the Living Body. Kagaku, 42(2), 79-85. (Japanese)

A review is presented of the effects of low dose irradiation. Topics discussed are: the concept of permissible dose; effects of 5 to 2^5 R doses on mutation induction in Drosophila and other studies on hereditary effects; experiments on silkworms and mice to determine relationships between dose rates and mutation; delayed effects of radiation on atomic bomb survivors in Hiroshima and Nagasaki; mechanisms for repair of radiation damage in relation to genetics; and application of the target theory in studies of hereditary effects of environmental pollutants. (HLW)

<240>
Tarasenko, N.Yu., and M.A. Khodyreva, Not given. 1968

Effects of Detergents on Skin and On the Absorption of Radioactive Substances. Hygiene and Sanitation, 33, 129-132.

The regular daily treatment of the skin of rabbits (weighing 2.5-3 kg) for 30 days with the most efficient detergents (pastes Nos. 11, 11 b, solution OP-7 with PC, soap No. 3, preparation "Zashchita-7" and 72% household soap) did not produce any marked irritant or allergic effects. A solution of Pu(+4) nitrate (0.4N) was applied to a 25 cm2 area of shorn rabbit skin so as to provide 1 uCi/cm2 Prior to the application of isotope, the skin area had been processed for 30 days with a solution of OP-7 with PC, paste No. 6 or No. 11b or household soap (control). For the experiment with an insoluble Pu compound, plutonium dioxide was applied to a shorn area of skin in the form of an aqueous suspension with kaolin so as to provide a dose of 0.5 mg of the pure element/animal. It was seen that percutaneous absorption of the soluble plutonium salt occurred in all cases, whereas the insoluble plutonium compound was not absorbed. The percutaneous absorption of plutonium nitrate was no higher after the use of special detergents than after the use of household soap. The experimental results permit the recommendation of detergent (including pastes Nos. 11(b) and f, solution OP-7 with PC, soap No. 3 and preparation "Zashchita-7") for the regular cleansing of the skin from radioactive contamination, while paste No. 11 can be recommended for final (additional) washings. (Auth) (FMM)

Table 1 shows Pu content in internal organs (liver, spleen, kidney, heart, lungs, muscles, bones) of rabbits. Table 2 shows effects of detergents on the absorption of Pu by rabbits.

<241>
Taylor, G.N., W.P. Christensen, L. Shadestari, and W.S.S. Jee, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1972

<241>

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The General Syndrome Induced by Plutonium 293 in the Beagle. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 59-74), 552 p.

The most critical factors in the toxicity syndrome induced in dogs by a single IV injection of tetravalent Pu 239 were the induction of bone cancer, hematopoietic changes, and liver lesions. Some of the less serious end points were pathologocial fractures, dental changes, and atrophy of the turbinates. These latter conditions produced functional impairment in only part of the dogs and principally at the higher dose levels. In the soft tissues, moderate thyroid atrophy and very focal kidney degeneration were induced by the 2.9 uCi Pu 239/kg dose, but neither of these changes were detectable clinically. An increased incidence of soft tissue neoplasia was also noted in the irradiated groups, but this was not unequivocally established as a Pu 239-induced factor. (Auth)

Table 1 gives incidence of pathological fractures following a single IV injection of Pu 239. Table 2 gives average time (months) of tooth loss in Pu 239 treated dogs. Table 3 gives the average weight of thyroid tissue in control dogs and dogs injected with Pu 239.

<242>
Taylor, G.N., W.R. Christensen, W.S.S. Jee, C.E. Rehfeld, and W. Fisher, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1962, March 31

Anatomical Distribution of Radiation-Induced Fractures in Beagles. COO-225; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 31-42), 136 p.

The anatomical distribution of bone fractures in beagles resultant to retained burdens of Ra 226, Ra 228, or Pu 239 indicated trends that were unique for the respective radionuclides. Three different dose levels were considered for each of the radionuclides. The fracture tabulations were obtained from radiographs taken at post mortem of the defleshed skeleton. Most of the animals died or were sacrificed because of bone tumors. Plutonium 239 induced the lowest number of limb bone fractures. Radium 228 produced the highest total incidence and the widest anatomical distribution. The Ra 226 cases more nearly resembled those of Ra 228, but the total number and distribution of fractures was lower. Involvements of the rib cage suggested patterns that were specific for the given radionuclides. (Auth) (FMM)

Figure 1 shows percentage incidence of fractures in beagles receiving a single intravenous injection of Ra 226, Ra 228 or Pu 239.

<243>
Taylor, G.N., T.F. Dougherty, and W.R. Christensen, University of Utah, College of Medicine, Medical Center Department of Anatomy, Salt Lake City, UT. 1971

Some Toxicity Aspects of Internally Deposited Plutonium 239. Part of Berdjis, C.C. (Ed.), Pathology of Irradiation, Chapter 7. Williams and Wilkins Company, Baltimore, Maryland (p. 110-119), 710 p.

Plutonium 239 was administered in the tetravalent form at pH 3.5, via a single intravenous injection to beagle dogs approximately 16 to 17 months of age. The results showed that most of the retained radionuclide burden was ultimately localized in the skeleton (approximately 60%) and the liver (approximately 30%). Much less significant deposition sites were the thyroid, the kidney and the spleen. The most significant aspects of the toxicity syndrome are summarized. The earliest clinically detectable radioinduced change was a drop in the leukocytes of the peripheral blood approximately 25% of the dogs injected at the highest level died with primary Pu-induced liver disease beginning at approximately 400 days post-injection. A moderate number of primary liver tumors occurred in the long-term low level animals. At the three highest dose levels of 2.8, 1, and 0.3 uCi/kg pathologic fractures occurred. The earliest fracture was observed approximately 390 days post-injection, with an average skeletal dose of 3,180 rads. An abnormal rate of tooth loss was first observed at the 0.0948 uCi/kg dose level and the rate increased with each successively higher dose. Another Pu-induced bone change was turbinate osteolysis. The leading cause of death following IV injection of tetravalent Pu 239 was the induction of osteosarcomas. These tumors occurred as low as the 0.0158 uCi/kg dose level and at an average cumulative skeletal dose as low as 60 rads. Some other conditions which developed and are considered as secondary to the overall radiation effect are lymphopenia, lymphatic hyperplasia, increased incidence of soft tissue tumors and decreased longevity. (FMM)

<244>
Taylor, G.N., and E. Hromyk, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1966, September 30

Liver Tumors in Beagles Injected with Plutonium 239. COO-119-235; Part of Dougherty, T.F., Research in Radiobiology, Semiannual Report of Work in Progress in the Internal Irradiation Program, (p. 71-75), 144 p.

The incidence of bile duct neoplasia in beagles injected with tetravalent Pu 239 (highest dose level being approximately 2.8 uCi/kg)) very tentatively indicates that such tumors may be radiation-induced. Most of these growths were relatively small benign adenomas and were observed as incidental findings at autopsy. Two malignancies were found in 87 cases studied. Hepatic cell carcinomas and primary liver hemangioendotheliomas have not been observed. (Auth)

<245>
Taylor, G.N., W.S.S. Jee, J.L. Williams, and I. Shahestari, University of Utah, College of Medicine, Radiobiology Division, Salt Lake City, UT. 1972

Hepatic Changes Induced by Plutonium 239. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah (p. 105-127), 552 p.

For several hundred days following a single intravenous injection of tetravalent Pu 239 in dogs (16-17 months of age), most of the liver burden was retained in the hepatic cells, but ultimately a high percentage shifted into the liver reticuloendothelial cells. The rate of translocation was

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greatest in the highest levels. The liver lesions thus induced consisted principally of hepatic cell necrosis followed by regenerative changes. Restoration of the lost cells was sufficient to maintain normal liver weights except in a few of the dogs injected at the highest level (approximately 2.9 uCi Pu 239/kg). Significant regenerative changes were produced at injected doses extending down to 0.0168 uCi Pu 239/kg and at average cumulative liver doses of less than 80 rads. Studies at still lower levels are in progress, but the relatively short latent periods presently preclude evaluation. Intrahepatic bile duct tumors were observed in 10 percent of the Pu 239-injected dogs surviving beyond 1000 days of age; however, most of these were small benign growths which were found incidentally at autopsy. Only twenty percent of the tumors were fatal malignancies. The incidence of bile duct neoplasms in the Pu 239-injected dogs was 2 1/2 times that of the controls, and all of the primary liver malignancies occurred in the Pu 239 groups. Other forms of primary liver neoplasia were not observed. (Auth)

<246>
Taylor, G.N., W.S.S. Jee, M.L. Dockum, E. Hromyk, and L. Brewster, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1966, March 31

Translocation of Plutonium 239 in Beagle Livers. COO-119-234; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 71-84), 326 p.

The initial liver deposition in the dog of tetravalent Pu 239, given intravenously (approximately 3 uCi/kg) in a citrate buffer (pH=3.5), was principally in the hepatic cells. However, at approximately 200-300 days post-injection a transfer to the Kupffer cells began, and subsequently redistribution to the portal regions occurred. During the migration the plutonium was closely associated with iron staining pigment and the translocation appeared resultant to its attachment on this iron containing colloid. The principal plutonium induced lesions in the liver consisted of modified regenerative changes rather than an immediate primary effect at the initial deposition site and occurred after long latent periods. (Auth)

Autoradiograms are present showing localization of Pu in beagle liver, following injection of approximately 3 uCi/kg Pu 239.

<247>
Taylor, G.N., C.E. Rehfeld, K.W. Crook, and W. Fisher, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1961, September 30

The Rate of Tooth Loss in Beagles Injected with Plutonium 239, Radium 226 and Radium 228. COO-224; Part of Dougherty, T.F., Research in Radiobiology, Semiannual Report of Work in Progress on the Chronic Toxicity Program, (p. 32-37), 104 p.

The rate of tooth loss in beagles injected with given doses of Pu 239, Ra 226 and Ra 228 was compared and the level at which a significant difference occurred was determined. The data were compiled from 1227 semi-annual dental examinations derived from 224 dogs. The rate of tooth loss induced by Ra 226, Ra 228 and Pu 239 tended to increase with successively higher injected doses after the injection level was raised above a certain minimum. This trend continued until the injected dose level was reached that reduced the post-injection lifespan below the latent period required for the occurrence of significant tooth losses. (Auth) (FNM)

<248>
Taylor, G.N., C.E. Rehfeld, P. Petermann, and K. Crook, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1962, March 31

Electrocardiogram Evaluation of Beagles with Retained Radionuclide Burdens. COO-225; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 43-47), 136 p.

Evaluation of the electrocardiograms of beagles ranging in age from 480 to 3449 days, with retained burdens of Ra 226, Ra 228, Pu 239, Th 228, or Sr 90 did not reveal any significant effect on the respective wave patterns or the time intervals of the P wave, PR segment, PR interval, of QRS interval. Maximum injected dose levels studied were as follows: 3.0 micron Ci/kg Ra 226, 10.0 uCi/kg Ra 228, 0.3 uCi/kg Th 228, 0.3 uCi/kg Pu 239, and 100 uCi/kg Sr 90 (Auth)

<249>
Taysum, D.H., D. Brammer, and C.E. Rehfeld, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1962, March 31

Alteration of the Metabolism of the Beagle by Radionuclides. COO-225; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 109-121), 136 p.

Subjective changes in the appearance of beagles that have received single intravenous injections of radionuclides that are principally bone seeking in character prompted the examination of their metabolism by means of calorimetry. Beagle dogs weighing about 10 kg were injected with Pu 239 in doses varying from 0.0491 uCi/kg to 0.308 uCi/kg, or Ra 226, the dose being 3.11 uCi/kg, or Sr 90 in a dose of 102 uCi/kg. It was observed that radionuclide burdened dogs produce approximately 10% more calories of heat per liter of oxygen than do the normal controls. Respiratory quotient and body temperature are not significantly altered by the radiation dose range, 0.003 to 10 rads per day mean skeletal dose, used in the study. The change in metabolism was seen to precede the formation of tumors. (Auth) (FNM)

<250>
Temple, L.A., S. Marks, and W.G. Bair, General Electric Company, Hanford Laboratories, Richland, WA. 1960

Tumors in Mice after Pulmonary Deposition of Radioactive Particles. International Journal of Radiation Biology, 2(2) 143-156.

Twelve-week old BaF1 or CAF1 female mice were used in the experiment. The intratracheal administration of plutonium and ruthenium particles suspended in Tween-80 (polyoxyethylene sorbitan monooleate) or Pluronics caused an increased incidence of pulmonary adenomas compared with controls at levels of 0.1uCi 239 PuO2 and 3.0 uCi

<250>

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<250> CONT.
106Ru02. Decreased incidence of adenomas was obtained at 0.16 uCi239 Pu02 and 24.0uCi 106Ru02. Intravenous administration of similar particles caused an increased incidence at a level of 0.16 uCi 239 Pu(OH)4 and a decrease at 0.37 uCi Pu 239 PuO2. Certain inconsistencies in the incidence values were noted. Dibenz (a,h) authoracene and methylcholanthrene were used as chemical carcinogens in different phases of the experiment to afford a comparison of the effects of chemical carcinogens with those of radioactive particles. Various combinations of chemical carcinogens and radioactive particles were also used. The dia of Pu 239 PuO2 particles ranged from 0.06 to 0.6 u with a mean of 0.5 mu. The mean particle dia. for Pu 106 Ru02 was 0.8 mu and for non-radioactive particles 0.9 mu.

<251>
Temple, L.A., S. Marks, and W.J. Bair, General Electric Company, Hanford Laboratories, Richland, WA. 1960

Tumors in Mice After Pulmonary Deposition of Radioactive Particles. International Journal of Radiation Biology, 2(2), 143-156.

Twelve-week-old BaF1 or CAF1 female mice were used in the experiment. The intratracheal administration of plutonium and ruthenium particles suspended in Tween-80 or pluronics (polypropylene glycolethylene oxide polymper) caused an increased incidence of pulmonary adenomas compared with controls at levels of 0.1 uCi Pu 239 PuO2 and 3.0 uCi Ru 106 PuO2. Intravenous administration of similar particles caused an increased incidence at a level of 0.16 uCi Pu 239 Pu(OH)4 and a decrease at 0.37 uCi Pu 239 PuO2. Certain inconsistencies in the incidence values were noted. Dibenz (a,h) anthracene and methylcholanthrene were used as chemical carcinogens in different phases of the experiment to afford a comparison of the facts of chemical carcinogens with those of radioactive particles. Various combinations of chemical carcinogens and radioactive particles were also used. The administration of methylcholanthrene, either done on with the agents caused the expected marked increase in tumor incidence. Histological lesions resulting from deposition of plutonium particles included fibrosis with bronchiolar proliferation and squamous metaplasia. Ruthenium particles caused the presence of numerous bizarre cells in fibrotic lesions. Plutonium particles were considered responsible for the development of two squamous-cell carcinomas and a bronchiolar carcinoma. Two bronchiolar carcinomas occurred in ruthenium-treated animals. (Auth) (FMM)

<252>
Temple, L.A., S. Marks, and W.J. Bair, Hanford Atomic Products Operation, Richland, WA. 1975, January 5

Tumorigenicity of Intratracheally Administered Particles. HW-59500; Part of Davis, J.J. (Ed.), Hanford Biology Research Annual Report for 1958, (p. 106-108), 156 p.

Suspensions of particles, radioactive and non-radioactive, in either 0.1 per cent Tween-80 or 0.1 per cent pluronics were administered intratracheally to two-month-old female BAF1 mice. Pneumonitis was observed in about five per cent of animals administered BASO4 or Pu 02 and 42 per cent of the animals administered Ru 106 RuO2. In two groups given Pu 239 PuO2 more than 70 per cent showed pneumonitis. Several malignant pulmonary tumors were seen following intratracheal injection of Pu 239 PuO2 or Ru 106 RuO2. Total doses to lung tissue, assuming a 30 day-biological half life and uniform distribution of particles, were estimated. (Auth) (FMM)

<253>
Thomas, R.G., Lovelace Foundation for Medical Education and Research, Inhalation Toxicology Research Institute, Albuquerque, NM. 1964

Influence of Aerosol Properties and the Respiratory Pattern Upon Hazards Evaluation Following Inhalation Exposure. CONF-448; STI/PUB/84; Part of Proceedings of a Symposium on the Assessment of Radioactive Body Burdens in Man held in Heidelberg, Germany, May 11-16, 1964, Vol. 1, (p. 355-368), 1043 p.

There are three important biological parameters which are necessary in evaluating the hazards from compounds entering the body by any route. These are (1) the amount deposited in the body; (2) the distribution and translocation kinetics within the body ; and (3) the rate of excretion of the material. Sufficient quantitative data on these points are generally lacking in the case of an accidental exposure. Experimental arimal studies correlating different physical and chemical characteristics of inhaled particles with the three biological variables mentioned above are described. Values for the amount and location of deposited material as a function of the particle size inhaled is presented for a tissue soluble compound (cesium chloride) and for a tissue "insoluble" compound (thorium chloride). Evidence is also given to substantiate the variations which occur in tissue distribution and excretion of an element, depending upon its physical and chemical state when breathed. Data from experiments with aerosols of many compounds, including those already mentioned, is used to show a unique correlation between body burden and fecal excretion during the first few post-exposure days. The advantages in performing analyses on both urine and feces for bioassay purposes are demonstrated. The fallacies in current methods of practical hazard assessment from air sampling and bioassay techniques are stressed throughout, using the above data as examples. (Auth)

Table 3 shows fecal to urinary ratios after inhalation of PuO2 in dogs and niobium oxadate in rats.

<254>
Thompson, P.C., W.J. Bair, S. Marks, and M.F. Sullivan, General Electric Company, Hanford Laboratories, Biology Operation, Richland, WA. 1958

Evaluation of Internal Exposure Hazards for Several Radioisotopes Encountered in Reactor Operations. A/CONF.15/1-P/2382; Part of Proceedings of the 2nd United Nations International Symposium on the Peaceful Uses of Atomic Energy held in Geneva, Switzerland, September 1-13, 1958, Vol. 23, (p. 283-289).

Selected aspects of the hazards from radioisotopes encountered in the operation of a Pu production plant are presented. The experiments described were concerned chiefly with Pu 239, the principal product of the Hanford Plant, and I 131, the most

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<254> CONT.
troublesore waste product of plant operation. Minor exposure incidents which have occurred point to four potential routes of plutonium entry to the body namely, puncture wounds from plutonium-contaminated objects, absorption through intact plutonium-contaminated skin, ingestion and inhalation. Extensive experiments with rats, involving chronic intragastric administration of plutonium over a wide range of concentrations, in solutions not more acid than pH 2, have indicated a fraction absorbed of 3 x 10(E-5). This figure has been confirmed in less extensive studies with pigs. Experiments are reported which compare the acutely toxic effects in rats of ingested, poorly absorbed alpha emitters (Pu 239) and beta emitters (Y 91), with the effects of x irradiation applied to the exteriorized intestine and to the intestine in situ. The LD 50 dose of Pu 239, administered intragastrically as the nitrate was about 90 mCi/kg. Survival time was less than 24 hr and death was probably due to nitrate toxicity. As much as 200 mCi of Pu 239 PuO2/kg was administered intragastrically without symptoms of radiation effects. This dose of Pu can be calculated to have delivered at the surface of the contents of the small intestine a radiation dose of approximately 1.5 x 10(E+6) rem. Experiments were performed with mice to determine both the distribution of the particles and the long-term pathological effects. Both Pu 239 PuO2 and Ru 106 RuO2 were administered by inhalation as aerosols and by intratracheal injection as hydrosols and the tissue distribution following intratracheal administration is shown. Malignant tumors were seen after 400 days in two of 17 animals injected intratracheally with 0.06 uCi of Pu 239 PuO2. The removal of internally deposited Pu by zirconium citrate, EDTA, DTPA and Vitamin A is discussed. Experiments involving the feeding of I 131 to sheep and the histopathologic and carcinogenic effects observed in the thyroid gland are reported. (FMM)

Table 2 shows tissue distribution following intratracheal administration of Ru 106, RuO2 and Pu 239 PuO2 (in lung, bone, adrenals, muscle, ovaries, spleen, liver, lymph and kidney).

<255>
Tombropoulos, E.G., W.J. Bair, and J.F. Park, General Electric Company, Hanford Laboratories, Biology Laboratory, Richland, WA. 1963, May 18

Effect of Diethylenetriaminepentaacetic Acid and Polypropyleneglycolethylene Oxide Polymer on Excretion of Inhaled Plutonium 239 PuO2 in Dogs. Nature, 198(4881), 703-704.

Eight 1-2 yr-old beagle dogs were exposed to plutonium oxide aerosols. Following exposure to Pu each group of dogs was exposed to an aerosol from an aqueous solution of one of the following: 25% Na3-Ca salt of DTPA, 10% pluronics (polypropyleneglycolethylene oxide), or 8% pluronics plus 2% gum arabic. One-hour treatments were given daily for 15 days. Urine and feces were analyzed for Pu. The Pu excretion rates of dogs treated with pluronics were consistently greater than those of untreated dogs. DTPA was less effective than pluronics in promoting excretion of Pu. Although pluronics increased the rate of excretion of Pu, there was no large effect on total body burden. Results indicate that neither DTPA nor pluronics is very effective in removing plutonium oxide from the lungs. (RAF)

The effect of DTPA and plutonics on whole-body clearance of inhaled Pu in dogs is given in graphic form. Tabular data are given on Pu distribution in dog tissues.

<256>
Totter, J.T., U.S. Atomic Energy Commission, Division of Biology and Medicine, Washington, DC. 1972

Biological Research with Plutonium, 1944-1984. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 23-27), 552 p.

Animal experiments using CF-1 mice to determine the toxicity of uranium and plutonium were performed at the Metallurgical Laboratory at the University of Chicago in 1944 by Brues, Lisco and Finkel. In 1947 these workers published a paper in Cancer Research entitled "Carcinogenic Action of Some Substances Which May be a Problem in Certain Future Industries", and a paper in Radiology entitled, "Carcinogenic Properties of Radioactive Fission Products and of Plutonium." In December, 1952, the first dog was injected at the University of Utah for the purpose of comparing the long-term biological effects of a single intravenous injection of Ra 226 and Pu 239 in adult beagles. The Utah project was established to verify the 0.04 uCi "whole body tolerance level" established for Pu 239 by the Chalk River, Canada, conference. Recently, emphasis has been on inhalation, non-uniform distribution of dose and bone cancer formation. (HP)

<257>
Tsarapkin, S.R., and Z.G. Sych, Not given. 1959

The Action of Plutonium 239 and Strontium 89, 90 On the Bone Marrow of White Rats. Meditsinskaya Radiologiya, 4(6), 75-77. (Russian, English Summary)

Experiments were carried on rats to study the reaction of bone marrow to intraperitoneal administration of 1.5 mCi/g of Sr 89, 90 and 0.0035 mCi/g of Pu 239. Analysis of bone marrow on the 3rd, 8th, 16th and 32th day following the isotope administration showed a greater sensitivity of cells of the erythropoietic series in comparison with cells of the granulopoietic series, the presence of the initial hypergenerative phase, increase of the number of generating cells and pathological mitoses. Effects of Pu on bone marrow compared to those of Sr were characterized by inhibition of the hypergenerative phase and lesions of reticuloendothelial and histiocytic cells. (Auth) (RAF)

<258>
Tseveleva, T.A., 1960, August-September

The Plutonium Content in the Protein Fraction of Rat Tubular Bones. Biochemistry, 25(1), 487-489, Biokhimiya, 25(4), 636-639.

Experiments (pH 6) were carried out on white male rats weighing 160-180 g. Plutonium was injected intraperitoneally as the citrate (pH 6) in the amount of 1.9 uCi/rat. Four protein compounds were isolated from bone tissue: collagen, albumoid, mucoid, and residual protein. Collagen made up 90% of the bone protein. Albumoids, mucoids, and residual protein made up 2.0, 1.6 and 6.9%

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<258> CONT.
respectively. All the bone proteins contained Pu. With collagen was bound 65-80%, with albumoid 15%; with mucoid 3.4%, and with residual protein 5% of the Pu. The metabolically active protein (albumoid) found 10 times more Pu/mg of N than do collagen and residual protein. The relative specific activity of mucoid surpassed by 2.5 times that of collagen, which might be explained by a share of the sulfate group of chondroitin sulfuric acid in the fixation of Pu. (RAF)

<259>
Tseveleva, T.A., and R.F. Libinzon, Not given. 1966

Influence of Plutonium 239 on the Free Ribonucleotide Metabolism in the Rabbit Liver. AEC-tr-6771; Part of Radiobiology, (p. 81-87,) 251 p., Radiobiologiya, 6(2) 218-223.

Experiments were conducted on gray rabbits of both sexes, weighing 2.0-2.5 kg. The animals received a single intravenous injection of a solution of Pu nitrate at pH of 2.0 in a dose of 7 uCi/kg. The nucleotide content and intensity of the incorporation of radioactive P into these compounds were investigated one and 15 days, one, two and six months after administration of the Pu solution. Four to six animals were used at each period. It was shown that Pu nitrate caused a substantial decrease in the nucleoside polyphosphate content in the rabbit liver. After one month, the ATP and GTP concentrations were approximately half the corresponding control values, while after three and six months they were nine and five times lower, respectively. A distinct increase in the nucleoside monophosphate content was noted in the livers of the experimental animals. In all periods of the investigation, a distinct decrease in the incorporation of radioactive phosphate into CDP-choline was detected, which may be the cause of the appearance of fatty dystrophy of the liver. A certain increase in the rate of incorporation of P 32 into the carbohydrate derivatives of uridine diphosphate occurred one month after the administration of plutonium, while after three months this process was 1.6 to 2.4 times as active as normal, and was accompanied by an intensification of the formation of connective tissue and the development of cirrhosis of the liver. (AUTH) (FMM)

<260>
Tseveleva, I.A., R.F. Libinzon, G.S. Musnkacheva, T.N. Rysina, and A.G. Surina, Ministry of Health, Institute of Biophysics, Moscow, USSR. 1968

Biochemical Changes in the Lungs of Rabbits After Inhalation of Plutonium. AEC-tr-7015; Part of Radiobiology, (p. 68-760), 238 p; Radiobiologiya, 8(4), 535-541.

The results of a study of the metabolism of the lung tissue after a single inhalation of ammonium plutonium pentacarbonate by rabbits (weighing 2.2-3.0 kg) in a dose producing sclerotic changes in the lungs are presented. A single inhalation of ammonium plutonium pentacarbonate at a dose of 0.5 uCi/g of lungs led to substantial changes in the metabolism of various compounds in the lung tissue. The metabolic processes in the lungs were sharply directed toward fibrillo-genesis from the first month after the treatment on. This was evidenced by an increase in the content of hydroxyproline (up to 114-125%) and mucopolysaccharides (up to 135-140%), which was already noted two weeks to one month after inhalation. From three months on, a more intensive incorporation of sulfur 35 into the sulfated mucopolysaccharides was observed. The most substantial changes during the first periods of investigation were noted in the lipids, phospholipids, and sialic acids. The content of these substances two weeks after inhalation was 185, 240, and 164% of the control, respectively. (Auth)

<261>
Twente, J.A., and W.S.S. Jee, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1961

The Determination of Localized Concentration of Plutonium 239 in Bone. Health Physics, 5, 142-148.

A microdensitometric technique of measuring localized concentrations of alpha-emitting radionuclides was used to determine the Pu 239 in bone. The data obtained by microdensitometric scanning of quantitative autoradiograms show close agreement with data obtained by the previously used technique of the visual counting of alpha-tracks. The accuracy of the microdensitometric technique was verified by a comparison of the Pu 239 content of a thoracic vertebral centrum determined microdensitometrically with the Pu 239 content of an adjacent centrum measured radiochemically. The amount of Pu 239 found microdensitometrically was 76 per cent of that determined radiochemically. The average Pu 239 concentration associated with haversian systems, periosteal surfaces, and endosteal surfaces of trabecular bone in a lumbar vertebra (from a beagle hound injected with 2.85 uCi of Pu 239/kg 92 days prior to sacrifice) was, respectively, 0.30 x 10(E-5), 0.54 x 10(-5) and 1.6 x 10(E-5) uuCi per u2 of surface. The calculated average localized dose rate delivered to bone tissue and marrow cells on the endosteal surface deposit is 40 and 60 rads per day. These rates are ten times the previously calculated average skeletal dose rate. (Auth)

<262>
Vaughan, J., Churchill Hospital, Bone Research Laboratory, Oxford, England. 1972

Bone Surfaces: What Are They?. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 323-332), 552 p.

"Bone surfaces" have a complex character. They consist of osteogenic cells lying on a mineral/matrix component which is made up of calcium apatite impregnating collagen fibers, and 'ground substance' composed of carbohydrate protein complexes, lipids and peptides. Plutonium deposited on "bone surfaces" is bound by osteogenic cells and their organelles, by specific bone glycoproteins and possibly by collagen. The presence of plutonium within or on the sensitive osteogenic cells accounts for the great carcinogenicity of this radionuclide. In discussion of metal binding by bone in the future it is not sufficient to talk of "bone surfaces". The constituent of the "bone surface" involved should be defined by experiment. (Auth)

<263>
Vaughan, J., B. Bleaney, and M. Williamson,

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<263> CONT.
Churchill Hospital, Medical Research Council, Bone-Seeking Isotopes Research Unit, Oxford, England. 1967

The Uptake of Plutonium in Bone Marrow: A Possible Leukemic Risk. British Journal of Haematology, 13, 492-502.

Observations are reported on the pattern of distribution of Pu 239 and of the radiation dose received in the bone marrow of the femur of young rabbits given a single intravenous injection of 1.25 uCi/kg of plutonium nitrate, and killed at subsequent time intervals. The total amount of Pu in the marrow fell by a factor of about 30 between 1 day and 7 months after injection. Initially, there were localized deposits of Pu, largely in macrophages containing an iron-containing pigment. There was also a diffuse distribution. The diffuse distribution fell off with time after injection, and at 7 months there were predominantly localized deposits of Pu. These contained about one-fifth of the amount of Pu seen in deposits 24 hrs after injection. The possible physiological and dosimetric interpretations of the pattern of distribution and the radiation hazard involved is discussed. It is suggested that marrow retention should be considered in determining maximum permissible levels of this radionuclide. (RAF)

<264>
Wager, R.W., N.L. Dockum, L.A. Temple, and D.H. Willard, Hanford Atomic Products Operation, Richland, WA. 1956, February 16

Toxicity of Radioactive Particles. 1A. Intratracheal Injection of Radioactive Suspensions. HW-41500; Part of Kornberg, H.A., et al, Biology Research Annual Report, 1955, (p. 61-72), 188 p.

A suspension of plutonium or ruthenium particles was injected intratracheally into 12-week-old BAF sub 1 female mice. The mean diameter of the Pu 10502 and PuOH4 particles was 0.8 and 0.5 u, and the diameter of the PuO2 particles ranged from 0.05 to 0.6 u.. Tween-80 was employed as a protective colloid. Fibrosis, epithelial hyperplasia, squamous metaplasia, and squamous cell carcinomas were observed 11 to 17 months in mice that were injected with plutonium oxide. Treatment with Ru 106 caused only necrosis and fibrosis. (Auth) (FMM)

<265>
Weeks, M.H., and W.D. Oakley, General Electric Company, Hanford Atomic Products Operation, Richland, WA. 1953, April 9

Percutaneous Absorption of Radioelements. HW-27688; Part of Research and Development Activities Quarterly Progress Report for January-March, 1953, (p. 16).

The absorption of plutonium through the skin of rats was studied over time-periods extending to one week. When applied as a 10 NHNO 3 solution of Pu(NO3)4, approximately 10% of the plutonium was absorbed by the animals at the end of one week. About 4% of the plutonium was absorbed during the first twenty-four hours. Rats similarly contaminated were subjected to permanganate-sulfuric acid decontamination procedure, which removed approximately 90% of the plutonium from the skin. The initial rate of absorption of the remaining 10% was markedly accelerated by the decontamination procedure. This has long been recognized as a potential risk of any decontamination procedure. Much more data are needed in this field, especially with skin more closely simulating the human case. (Auth) (Complete Text)

<266>
White, M.F., and J. Schubert, Argonne National Laboratory, Division of Biological and Medical Research, Chicago, IL. 1952, January-April

The Action of Salts of Zirconium and Other Metals on Plutonium and Yttrium Distribution and Excretion. Journal of Pharmacology and Experimental Therapeutics, 104, 317-324.

Adult female rats were injected either intraperitoneally or intravenously with tetravalent Pu 239 in a 1% sodium citrate solution, pH 4-7. Each rat received between 10 and 20 ug in different experiments. Approximately 1 uCi of Y 91 was added to the Pu solution in some experiments. Treatment solutions were injected intraperitoneally or intravenously at different tissues from 8 days before to 24 hours after the radioelements. Treatment of rats with zirconium prior to injection of plutonium and yttrium lowered the amount of Pu and Y subsequently deposited in the skeleton and increased the amount of Pu in the kidneys. The deposition of both Pu and Y in the bone was correlated with the length of time between pretreatment and their injection. Zr injected 24 hours after Pu and Y prevented further deposition of the radioelements in bone, but had no other observable effect on their organ distribution. In addition to Zr other hydrolyzable elements-manganese, iron, titanium, aluminum, and thorium-reduced bone deposition of Pu, but had various effects on the amounts deposited in other organs. Al and Th increased the Pu content of the liver and other soft tissues. Non-hydrolyzable magnesium had no significant effect on the distribution of either Pu or Y. The mechanisms by which salts of Zr and other hydrolyzable elements may affect Pu and Y metabolism is discussed. This includes adsorption of the radicelement on colloidal aggregates in the circulation and the relation between particle size and the resulting distribution of the aggregate plus adsorbed radioelement. (RAF)

The effects of pretreatment with Zr on the distribution of Pu 239 and Y 91 are given in tabular form.

<267>
Willard, D.H., Hanford Atomic Products Operation, Richland, WA. 1960, January 15

Distribution and Toxicity of Inhaled Plutonium 239 Dioxide. HW-65500; Part of Kornberg, H.A., Hanford Biology Research Annual Report for 1959, (p. 122-128), 208 p.

Adult beagle dogs were exposed to Pu 239 PuO2 aerosols of varying concentrations and particle size. Between 53 and 63% of the total Pu 239 PuO2 deposited was present in the lung for two weeks after exposure. The extremely small quantities found in bone and other organs demonstrated the insolubility of Pu 239 PuO2. Other dogs depositing 25 to 150 uCi Pu 239 PuO2 died within 50 to 75 days. Death was preceded by decreasing total lymphocyte counts and increasing respiratory rate. (Auth)

<268>

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<268>
Wilson, R.H., and J.L. Terry, University of Rochester, Rochester, NY. 1968

Biological Studies Associated with a Field Release of Plutonium. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2, Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 273-290), 680 p.

Three hundred dogs, sheep and burros were exposed to plutonium aerosol generated by a high-explosive detonation. Initial lung burden for the three species were 22.6, 10.6 and 17.7% of the respirable (less than 10 u) particles, respectively, and of these burdens 67, 5.1 and 22% was cleared slowly. Early clearance showed half-times of 4.5 and 10 days, but the data were inadequate to establish a slow clearance half-time different from the usually accepted 365 days. Ten dogs and ten sheep were exposed to similar aerosol in concert with a large amount of inert dust, and these animals showed 4-5 times greater clearance in the first 7 days. No data are available for extrapolation beyond 7 days. (Auth)

<269>
Yerokhin, R.A., N.A. Koshurnkova, V.K. Lenberg, A.P. Nifatov, and A.A. Puzyrev, Not given. 1971

Some Remote Aftereffects of Intratracheal Administration of Chemically Soluble Plutonium 239 Compounds. AEC-tr-7387, Part of Remote Aftereffects of Radiation Damage, (p. 344-363), 574 p.

Wistar rats weighing initially 140-160 g were injected intratracheally solutions of plutonium nitrate (pH 2), sodium plutonyltriacetate (pH 6.5), and nitric acid (pH 2). The Pu compounds were given in 7 series in doses of 0.00042, 0.0042, 0.01, 0.031, 0.048, 0.1, 0.42 and 1 uCi. Rats administered plutonium nitrate in doses 0.42-1 uCi and sodium plutonyltriacetate in a dose of 1 uCi/rat showed a considerably reduced mean lifetime in comparison with the control animals and with rats administered nitric acid. The microdistribution of Pu in the lungs and regional lymph nodes at remote times after administration was characterized by a well-expressed nonuniformity. A reliable increase in the frequency of pneumosclerosis was observed in rats administered Pu in doses of 0.048-1 uCi in comparison with animals given nitric acid. The optimum blastomogenic dose for plutonium nitrate was 0.42 uCi. An increase in the frequency of occurrence of pulmonary cancer was seen in animals given Pu in doses 0.42-1 uCi when compared to animals given nitric acid. Sodium plutonyltriacetate lead to a more frequent occurrence of pulmonary cancer in comparison with plutonium nitrate at same dose levels. An increase in extrapulmonary tumors, for the most part due to osteosarcomas, malignant tumors in the gastrointestinal tract, and tumors of the endocrinal glands was seen in rats given radionuclides. After administering plutonium nitrate in doses of 0.048-1 uCi the frequency of occurrence of osteosarcomas was dependent on the Pu dose and the total ionization dose in the skeleton. In comparison with plutonium nitrate (in equal quantities) sodium plutonyltriacetate had a more clearly expressed osteosarcomogenic effect. (RAF)

Extensive tabular data are given of all experimental results.

<270>
Yukhlov, A.K., and R.A. Knyazeva, Not given. 1964

Changes in the Absorption Characteristics of Cerebral and Renal Tissue after the Incorporation of Radioactive Fission Products of Uranium 235 in Low Doses. AEC-tr-6406, Part of Radiobiology, (p. 50-57), 211 p., Radiobiologiya, 4(3), 370-374.

When mice are given radioactive fission products of uranium 235 by gavage in doses of 0.01 and 1 mCi per kilogram an increase is noted in the adsorptive activity of the cerebral (25 percent) and renal (72 percent) tissues, which reaches a maximum on the first-third day after the administration. The dynamics of changes in the adsorptive characteristics of the renal and cerebral tissues attest to possibilities of compensatory recovery of the protein substrate of the renal and cerebral tissues toward the end of the first week after the animals are given a mixture of uranium 235 fission products. (Auth)

<271>
Zalikin, G.A., Yu.I. Moskalev, A.I. Semenov, Ye.S. Zhorova, V.N. Strel'tsova, I.K. Petrovich, and V.I. Trifonov, Not given. 1974, February

Materials on the Toxicology of Californium 252. CONF-730907 (Part 1), Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 117-128), 1475 p. (Russian, English Summary)

The report contains data on accumulation, distribution and elimination of various compounds of Cf 252 from the body of animals and characterizes its biological action after a single intravenous injection of acutely, subacutely and chronically effective doses. Symptoms of acute, subacute and chronic injury by Cf 252 are described and characteristics of its blastomogenic efficiency as a function of dose is given. (Auth)

<272>
Zalikin, C.A., and V.I. Trifonov, Not given. 1972

Distribution of Americium 241 in the Rat Organism, As Related to the Properties of the Administered Salt. AEC-tr-7457, Part of Moskalev, Yu.I. and Kalistratova, V.S. (Eds.), Biological Effects of Radiation from External and Internal Sources, (p. 427-434), 515 p.

Investigations were conducted on female albino rats weighing 200 plus or minus 10 grams. A trace preparation of Am 241 was dissolved in nitrate, chloride and citrate solutions, pH 3.0. The concentration of the citrate solution of isotope constituted 0.2%. The specific activity of the solutions was in the range of 0.9-1 uCi/ml The solution of polymeric form of americium had a specific activity of 0.49 uCi/ml, pH 10.0. All four preparations were administered in the caudal vein of the rats. At specific intervals following administration of the isotope, the rats were sacrificed and determination was made of activity level according to gamma-emission in samples of different organs and tissues. The Am 241 content in organs was expressed as percentage of injected

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doses. The results show that the distribution of Am 241 in the rat organism is of the hepatic type since considerably greater (by 2-3 times) accumulation of the isotope is observed in the liver as compared to the skeletal system and it is little related to the properties of the administered salt. The americium content of the skeletal system following intravenous administration of soluble salts of this isotope does not exceed 21% of the administered dose. In the case of intravenous injection of the polymeric form of Am 241 (hydroxide), an additional "reservoir" of the isotope is formed in the lungs where up to 44% of the injected dose is retained. (Auth) (PHM)

Table 90 shows Am 241 content in lower skeletal system, lungs, spleen and kidneys of rats after IV administration of different salt solutions of the isotope (% of injected dose.)

<273>

BIOLOGICAL ASPECTS
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<273>
Adams, W.H., J.P. Buchholz, C.W. Christenson, G.L. Johnson, and F.P. Fowler, Los Alamos Scientific Laboratory, Los Alamos, NM. 1975, January

Studies of Plutonium, Americium, and Uranium in Environmental Matrices. LA-5661; 24 p.

A nitric acid-hydrofluoric acid treatment for dissolution of plutonium oxides in soils has been developed; its adaption to other biological matrices is discussed. Plutonium recoveries of 94 to 99% from 1-g samples of spiked and heated soils are reported. Adaptation of the acid solution to subsequent anion exchange separation of plutonium, followed by coupling to known electroplating techniques, is described. The uptake of plutonium, americium, and uranium from spiked soils by alfalfa, beans, radishes, lettuce, tomatoes, and barley is reported. The "apparent" solubility of Pu 238 PuO2 in tap water was measured, and the deposition of plutonium in fish, algae, and snails in aquaria containing Pu 238 PuO2 microspheres is reported. (Auth)

<274>
Garland, T.R., R.E. Wildung, J.W. Neel, and D.A. Cataldo, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1974, December

Factors Affecting Uptake and Distribution of Plutonium in Barley and Soybean Plants. BNWL-1950 (Part 2); Part of Vaughan, B.E., et al, Annual Report for 1974, (p. 30-36), 238 p.

Barley and soybean plants were grown on soils amended with Pu(NO3)4 using the split-root technique. Parameters investigated included the effects of 1) soil volume and soil column height, 2) starch and N amendments to optimize microbial activity, 3) soil type, and 4) increased levels of Pu addition (100 Nu Ci/g), on the uptake and distribution in barley. The distribution of Pu was determined in tops and roots of soybeans after 50 days of growth and barley after 27 days of growth. Increases in the total volume of soil resulted in only slight increases of total plant uptake. The height of the soil column appeared to be the most important variable. Increased uptake in the taller soil column was likely due to the increased contact of individual roots with Pu-containing soil. Incubation of Ritzville soil with N and C markedly increased Pu uptake by the roots. Elevation of the soil Pu levels to 100 Nu only slightly increased Pu uptake compared to the 10 uCi/g level. Measurements of distribution of Pu in the shoots and roots of barley indicated that Pu, once in the plant, was rather mobile. Older leaves showed accumulation near the base of the blade, with the middle of the plant deficient and increased levels near the tip. In younger blades, the gradient was continuous with the base of the blade exhibiting the lowest concentration of Pu and the tip the highest levels. In the roots the gradient was reversed. The distribution of Pu in soybean tissues was, in general, similar to that found in barley. At about 7 days of growth the soybean plants developed a disorder that limited the production of seeds. Barley seeds, harvested after 100 days of growth, did not contain Pu in detectable quantities. (RAF)

All the investigated parameters are given in tabular form.

<275>
Hsieh, J.J.C., F.P. Hungate, and W.C. Roesch, Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA; Battelle Memorial Institute, Pacific Northwest Laboratories, Environmental and Radiological Sciences Department, Richland, WA. 1968, May

Temperature of Surfaces in Contact with Plutonium 238 PuO2 Microspheres

In the course of observing effects of Pu 238 PuO2 microspheres on leaf surfaces, the question arose as to the relative importance of ionization versus simple heat effects. Results of experiments showed that the temperature of a well-ventilated surface in contact with a 200 u diameter Pu 238 PuO2 particle may rise to 350-400 F as measured by heat-sensing "ThermaTab" strips. The possibility that leaf damage from Pu 238 microspheres could be due to thermal effects was heightened by observing that touching the tip of a hot glass rod to leaf surfaces produced damage visibly comparable to that from the Pu 238. On the other hand, it is not certain that the melting and blackening of ThermaTab may not be a consequence of ionization-induced breakdown of lattice structure rather than due to purely thermal effects. (Auth) (PMM)

<276>
Kornberg, H.A. (Ed.), and E.G. Siezea (Ed.), Hanford Atomic Products Operation, Biology Laboratory, Richland, WA. 1962, January 15

Hanford Biology Research Annual Report for 1961. HW-72500; 180 p.

The traditional emphasis in the scientific program of the biology section has been on internal emitters. The toxicity in swine of intravenously administered Sr 90, Ra 226, and Pu 239 were compared. In a broad inhalation studies program, toxicity and related properties of several radionuclides were studied. The results of several diversified studies in animal and cellular physiology are included. The uptake of arsenic from different soils as affected by phosphate was measured. The uptake of calcium and rubidium by young plants seemed to occur via an active carrier system, since an inhibition of protein synthesis decreased uptake. Field and laboratory studies indicate that columnaris disease increases with crowding among fish and that x-irradiating the organism does not produce a more virulent strain than the parent stock. Six papers from the annual report were abstracted separately for the data base. (HP)

<277>
Miller, C.F., Not given. 1968

The Nature and Behavior of Local Fallout. CONF-680507; Part of Proceedings of a Symposium on Radiological Protection of the Public in a Nuclear Mass Disaster held in Interlaken, Switzerland, May 26-June 1, 1968, (p. 49-64), 688 p.

The general nature of fallout particles is discussed briefly in terms of the processes leading to their formation in the nuclear fireball and rising cloud. Inhomogeneities in the clouds are given as a reason for the dispersion and fragmentation in the observed fallout patterns. Most attention has been given to details of the deposition processes and the behavior of the fallout particles

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<277> CONT.
during and after their contact with exposed surfaces with emphasis on the interception and retention of particles by plants. The retention of fallout particles by plant foliage depends mainly on the size and shape of the plants, plant spacing and density, wind speed, particle fall angle (i.e., particle size), exposure time, rainfall, humidity, and plant growth rates. With a few exceptions, the surface characteristics of the foliage is a second order variable. The dependency of the retention on several of these variables is illustrated by data obtained in Costa Rica for the cereal grains barley, oats, and wheat, and for a small camphor tree. The representations shown of the contamination of vegetation by airborne particles form the basis for evaluating the beta and gamma dosages that plants may receive from fallout and, to some degree, the input information for the entry of radionuclides in several food chains. Data on personnel contamination are rather scarce but the few data available indicate that hair retains particles with a fairly high degree of efficiency. (Auth) (F&M)

Figure 1 shown the variation of estimated specific activity with particle size for shot Small Boy (detonated near ground surface at the Nevada Test Site).

<278>
Soldat, J.K., and R. Klepper, Battelle Memorial Institute, Pacific Northwest Laboratories, Environmental and Life Sciences Division, Ecosystems Department, Richland, WA. 1974, January

Radiation Doses from Iodine 129. BNWL-1850 (Part 2); Part of Vaughan, B.E., et al, Annual Report for 1973, (p. 42-44), 200 p.

A summary of a report dealing with I 129 levels found in soils and vegetation and the resulting radiation doses to man and biota is presented. It is assumed that because of its long half-life I 129 will become part of the total iodine pool of any ecosystem. The ratio of I 129 to I 127 available to living organisms will determine radiation doses received by them. External doses will be insignificant compared to internal doses because of the low beta and gamma radiation energy. The major factor in plant contamination is via aerial deposition on leaves; the soil-root pathway becoming more important with time. The organ of interest in many organisms is the thyroid with a dose pathway of ingestion rather than inhalation. Principal foods of concern are milk, vegetables, meat, drinking water and aquatic foods. The calculated dose rates to the human thyroid of various ages exceed maximum permissible dose rates under the assumptions that all iodine in the thyroid were I 129. The adult dose rates are 34 times higher than the MPDP, the one-year-old child would received 9 times the dose in the present guide. (RAF)

Table 2.12 shows human dose rates to the thyroid from I 129 (mrem/yr) at age 1, 4, 14 and adult assuming all iodine to be I 129.

<279>

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<279>
Akatsu, J., Japan Atomic Energy Research Institute, Tokai, Japan. 1974

Recovery of Plutonium and Americium from Alpha-Bearing Aqueous Wastes. 3.. Radiochemical and Radioanalytical Letters, 19(1), 33-42.

When Pu and Am were fixed as their hydroxides from alpha-bearing aqueous wastes, trace amounts of them remained in the solutions. It was found in alkaline solution that Pu(+3) and Pu(+6) are instantly converted into Pu(+4) with dilute H2O2, at room temperature, and Pu(+4) can be fixed by scavenging with Fe0H3. Approximately 6 g of Pu and 12 mg of Am were recovered from about 90 l of miscellaneous aqueous wastes approximately 7 mCi/l, with a recovery efficiency of > 90%. The alpha activities of supernatant solutions were approximately 3 uCi/l. (Auth)

<280>
Akatsu, J., Japan Atomic Energy Research Institute, Tokai, Japan. 1974

Recovery of Plutonium and Americium from Alpha-Bearing Aqueous Wastes, 2.. Radiochemical and Radioanalytical Letters, 19(1), 25-32.

From alpha-bearing aqueous wastes, Pu and Am were fixed as their hydroxides and separated by decantation. The supernatant solutions were decontaminated with Fe0H3, the slurry was dissolved with HNO3 to give a Ca or Na-nitrate solution, from which Pu and Am were recovered by DBP or TBP solvent extraction. Approximately 8 g of Pu and 130 mg of Am, with about 85% yield were recovered from 130 l of aqeuous wastes containing approximately 12 mCi, alpha/l. The gross alpha-activity in the decontaminated solution was approximately 10 uCi/l. (Auth)

<281>
Bagnall, K.W., Atomic Energy Research Establishment, Chemistry Division, Harwell, England. 1964

The Transuranium Elements. Science Progress, 52, 66-83.

The discovery of the transuranium elements has resulted in the development of new techniques in the physical sciences and has played a part in the renaissance of inorganic chemistry. Their place in the periodic classification is described as are their various valency states. Oxides and other compounds are listed. Radioactive hazards in working with these elements are discussed and methods of handling indicated. (Auth)

<282>
Bruenger, F.W., W. Stevens, and B.J. Stover, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1967, March 31

On the Binding of Plutonium(+4) to Transferrin and Conalbumin. COO-119-236; Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 191-195), 268 p.

The binding of Pu 239(+4) by transferrin and conalbumin requires the presence of HCO3. Terminal sialic acid groups of transferrin are not involved in binding of Pu(+4) to the protein. Conformation changes caused by removal of sialic acid residues do not effect the binding ability for the nuclide. Structural changes induced by an enzymatic attach on the glycopeptide groups lead to the loss of binding ability for plutonium but not for iron. (Auth)

<283>
Bruenger, F.W., B.J. Stover, and D.R. Atherton, University of Utah, College of Medicine, Salt Lake City, UT. 1962, September 30

Solvent Extraction of Plutonium with Primary Amines. COO-226; Part of Dougherty, T.F., Research in Radiobiology, Semiannual Report of Work in Progress on the Chronic Toxicity Program, (p. 58-65), 135 p.

An accurate and simple procedure for the determination of plutonium in biological materials has been developed. Concentrated urine, or a solution of bone ash, was made at least 1M in H2SO4, and plutonium was extracted with a mixture of C 18 to C 23 highly branched primary amines in xylene. Plutonium was then extracted from the organic phase with 8M HCl and measured by alpha counting. (Auth)

<284>
Delle Site, A., G. Santori, and C. Testa, Comitato Nazionale per l'Energia Nucleare, Rome, Italy. 1974, February

The Rapid Determination of the Transuranium Elements by Extraction Chromatography in Urines Containing DTPA. CONF-780907 (Part 1); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 532-537), 1475 p.

Microporous polyethylene (Microthene-710) supporting tri-n-octylphosphine oxide (TOPO) and di(2-ethylhexyl) phosphoric acid (HDEHP) has been used successfully to extract respectively Th, Pa, U, Np, Pu, Am and Cm from the urine. As the extraction takes place in an HNO3 medium, DTPA up to 2 g/l does not interfere. A special investigation was carried out for Am in order to find out the best extraction pH. Finally it has been demonstrated that great losses of actinides occur when a coprecipitation with Ca and Mg phosphates are carried out in the presence of DTPA. (Auth)

<285>
Jackson, M.L., University of Wisconsin, Madison, WI. 1974

Exchange of Lyotropic Series Cations by Micaceous Vermiculite and Its Weathering Products Determined by Electron Microscopy and Radiochemical Analysis. COO-1515-56; Progress Report for the Period Ending August 1, 1971-July 31, 1974; 30 p.

The work is summarized under three topics: (1.) fission particle tracks of U 238 present in the octahedral sheet of micaceous vermiculite, after HF decoration, were photographed by scanning electron microscopy. Before HF treatment, diffusion of K(+1), Fe, and Si(OH)4 was enhanced by the presence of the tracks, and selective adsorption of fixing cations such as Cs 137(+1) was increased. High resolution electron microscopy (HREM) revealed that the mixed-layer stacking sequence of most clays contain some micaceous vermiculite. Lateral variation along the (001) crystal planes was shown by blister morphology and also by HREM, thus demonstrating conclusively the existence

<285> CONT.
of interlayer wedges active in selectivity of such cations as Cs(+1). (2.) Divalent cations of the Sr 90(+2) type and transition and heavy metal type are specifically sorbed by gel forms of hydrous oxides of Fe(+3) and Al(+3) which are almost universally present as coatings on soil particles. (3.) Tropospheric dusts, shown to circulate world-wide and accrete in soils, deep-sea sediments, and island mountain tops from rainfall, show significant reactions with fission products such as Cs 137(+1) and Sr 90 (+2), variable according to dust composition. They influence the fate of radioisotopic fission products in air and soil. A summary of the findings is given, with references to the specific publications in which they are reported. (Auth)(CTS)

<286>
Kay, A.E. (Ed.), and M.B. Waldron (Ed.), United Kingdom Atomic Energy Authority, Harwell, England. 1967

Plutonium 1965. CONF-651102; Proceedings of the Royal Commonwealth Society 3rd International Symposium on Plutonium held in London, England, November 22-26, 1965. Chapman and Hall, London, England, 1114 p.

At the conference studies on Pu in metallic form was described as well as the current knowledge of Pu ceramics. The papers were grouped into technical sessions with the following headings: transformation studies, alloy systems, mechanical properties, corrosion, studies on ceramic fuels, ceramic phase studies and irradiation behavior. (FMM)

<287>
Ludwick, J.D., General Electric Company, Hanford Laboratories Operation, Richland, WA. 1961

The Analysis of Plutonium 241 in Urine. Health Physics, 6, 63-65.

A method has been developed for the quantitative determination of plutonium 241 in exposed personnel through urine analysis, and was designed for use, when necessary, in conjunction with the Hanford plutonium bio-assay technique of alpha analysis. This method is based on the recovery of plutonium from electro-deposited disks and subsequent extraction of the plutonium from 1 N hydrochloric acid into a liquid scintillator containing dibutyl phosphate. Plutonium 241 beta emission is detected in a standard liquid scintillation spectrometer, and the yield for plutonium recovery using spiked samples of Pu 241 was 85 plus or minus 9 per cent. Samples containing as little as 2.2 x 10(E-6) uc of Pu 241 may be reliably detected, which represents 3.5 per cent of the maximum permissible dose 90 days after personnel exposure. (Auth)

<288>
Matlack, G.M., Los Alamos Scientific Laboratory, Los Alamos, NM. 1974, December

The Chemistry of Plutonium in Relation to Its Behavior in Biological and Environmental Systems. CONF-740115; Part of Proceedings of the Plutonium Information Symposium held in Los Alamos, New Mexico, January 4-5, 1974, (p. 2-7), 96 p.

Plutonium metal is silvery-white at room temperature and in the absence of any surface oxidation. It is hard and brittle with a density close to 20 and melting point of 640 degrees C. The solid metal exists in six allotropic modifications, each of which has different mechanical properties, such as different densities and hardnesses. Pu dissolves slowly in water; the common dissolution agents in the laboratory are HCl and HBr. The alpha activity of Pu ranges from about 3 billion dis/sec/g to over 10 billion. This range comes from the fact that Pu produced at high burnups and then recycled shows an increasing fraction of the Pu 238 and Pu 240 isotopes, which have shorter half-lives than Pu 239. A typical isotopic distribution in reactor-grade Pu might be 88% Pu 239, 10.6% Pu 240, 1.2% Pu 241, 0.2% Pu 242, and only 0.02% Pu 238. There are x rays and gamma rays that are associated with the decay of Pu, although they are not nearly as abundant as the alpha particles. The solid compounds of Pu display a wide range of colors, for example the fluoride is blue-green, the sulfide golden bronze and the chloride is green. Pu in solution shows five oxidation or valence states ranging from the trivalent to the heptavalent. All four of the common Pu oxidation states (3, 4, 5 and 6) show a tendency to hydrolyze; Pu(4) is the oxidation state most subject to hydrolysis and Pu(V) is the least subject. A unique reaction of Pu in solution is disproportionation: that is, starting with any one oxidation state of Pu, you could wind up with all four. In water solution, Pu has the tendency to polymerize. The Pu ions can form first a dimer, and then the oxygen bridge formation tends to continue until large collodial aggregates, or polymers, exists, whose molecular weights exceed 200,000. The polymer is bright green and is inert to nearly all the ordinary reactions of Pu. Some of the anions that form complexes with Pu are F-, Cl-, CO3--, SO4-- and SO3--. The complex stability decreases as the charge on the Pu ion decreases and the divalent negative ions are usually stronger complex formers than the monovalent negative ions. Anion-exchange processes are important for the purification of Pu and several elements can be removed from Pu with an efficiency greater than 99.9%. (FMM)

<289>
Mikhailova, O.A., N.S. Shvydko, and D.K. Popev, Not given. 1973, August

Method of Determining Plutonium 239 in Urine. Gigiena i Sanitariya, 8, 69-71.(Russian)

Since published methods for Pu 239 determination generally recommended reagents and resins not available commercially in the USSR, locally available materials were investigated. A method was developed in which Pu(+4) as the cupferronate is separated from macro impurities by chloroform extraction from a nitric acid medium using zirconium carrier or no carrier. Am 241, U, Th, and 3% of the Pu 239 remained in the aqueous phase. The Po 210 was removed from the plutonium by precipitation on a nickel disk or with mercury. After removal of the chloroform from the organic phase, the Pu 239 was precipitated with ammonia, using a lanthanum carrier, and was counted after further processing. The Pu can also be electroprecipitated . (TTT)

<290>
Nelson, D.M., E.M. Yaguchi, B.J. Waller, and M.A. Wahlgren, Argonne National Laboratory, Argonne, IL. 1973

<290>

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<290> CONT.
Radiochemical Methods. ANL-8060 (Part 3); Part of Radiological and Environmental Research Division Annual Report, January through December, 1973, (p. 6-17), 187 p.

Techniques to measure Pu 239, Pu 238, Sr 90, Cs 137, and mixed gamma-emitting nuclides in samples of fresh water, organisms, and sediments are described. The procedure for initial separation from water samples, sediment, fish, plant and invertebrate samples is outlined and details for the radiochemical analysis of Pu, Cs and Sr are then given. Known activities of Pu 242, Sr 85, and a known weight of stable cesium are added to each sample initially and then used to determine radiochemical recoveries. The preparation of Pu 242 of extremely high radiochemical and isotopic purity is described. The use of this spike permits accurate measurement of radiochemical yield, while maintaining a very low background in the regions of interest. Most of the determinations of gamma-ray emitting radionuclides employ a 10- x 10-cm NaI(Tl) crystal coupled to a 400-channel pulse height analyzer. Output from this analyzer is directed simultaneously to a typewriter for permanent copy and to a keypunch to permit computer data analysis. (FMM)

<291>
Sandalls, F.J., and A. Morgan, Atomic Energy Research Establishment, Health Physics and Medical Division, Harwell, England. 1964

A Procedure for the Determination of Alpha-Emitting Plutonium in Urine Using a Solid-State Counter. CONF-448; STI/PUB/84; Part of Proceedings of a Symposium on the Assessment of Radioactive Body Burdens in Man held in Heidelberg, Germany, May 11-16, 1964, Vol. 1, (p. 261-274), 1043 p.

A method for the routine determination of alpha-emitting plutonium in urine is described. In evolving this procedure various techniques for concentrating, purifying and electrodepositing plutonium were compared, and these investigations are summarized. In the procedure finally adopted, urine is wet-ashed and the residue dissolved in hydrochloric acid. Plutonium (+4) is precipitated with iron cupferride from this solution and extracted into chloroform. After evaporation of the chloroform, the residue is oxidized, dissolved in hydrochloric acid and the iron extracted into di-isopropyl ether. The aqueous phase containing the plutonium is evaporated and dissolved in an acid ammonium sulphate solution from which the plutonium is electrodeposited onto stainless steel. Quantitative recoveries are obtained in the electrodeposition stage and an overall recovery of 84 plus or minus 7%. The electrodeposited plutonium is counted with a solid-state (silicon junction diode) detector in a counter developed for this purpose. The low inherent background of this type of counter is effectively reduced still further by counting only those alpha particles with energy in the 4.2-5.4 MeV range. The good resolution which can be obtained with thin electrodeposited sources of plutonium enables this narrow channel to be used with only small losses in counting efficiency. By counting over this restricted energy range, the blank activity arising from reagents and incomplete removal of alpha-emitting contaminants in urine is also reduced by a factor of two, to just over 0.1 pCi/24-h sample. The limit of detection with this method is about 0.025 pCi of Pu 239. (Auth)

<292>
Schwendiman, L.C., and J.W. Healy, Hanford Atomic Products Operation, Richland, WA. 1958

A Sensitive Analytical Method for the Determination of Very Low Level Plutonium in Humans. Part of Proceedings of the 2nd United Nations International Symposium on the Peaceful Uses of Atomic Energy held in Geneva, Switzerland, September 1-13, 1958, Vol. 23, (p. 144-146).

In the new method described, nuclear track emulsions replace the electronic counters used in the previous method as the alpha particle detector. The analysis separated the plutonium from the urine sample and ddeposited it uniformly on to a small disk. This disk was held against the nuclear track emulsion efficiency, area examined, area of eposit and exposure time. An electrodeposition cell was develcped and multiposition equipment designed to permit simultaneous analysis of as many as twenty samples. The nuclear track emulsion chosen tc record the alpha particles emitted was Kodak NTA emulsion 25 u thick on 1 by 3 in microslides. Optimum deve-oping time was determined to be 6 min in D-19 developer at 68 degrees F plus or minus 2 degrees. A radioautographic "camera" was constructed, permitting the simulataneous exposure of 8 disks. A scanning system of counting was used. The particular advantage of this method is that there is virtually nc limit to its ultimate sensitivity since by a combination of reducing the source size and increasing the exposure time almost any desired sensitivity should be obtained. In a routine bioassay program designed to discover incipient plutonium expcsures and identify such individuals who may require work with less chronic exposure liability, this method has proved reliable, sensitive, and adequately precise. (FMM)

See also Nucleonics, 16(6), 78-81

<293>
Schwendiman, L.C., and J.W. Healy, Hanford Atomic Products Operation, Richland, WA. 1958, June

Nuclear-Track Technique for Low-Level Plutonium in Urine. Nucleonics, 16(6), 78-81.

A nuclear-track-emulsion technique has been developed that is adequately sensitive and reproducible. The plutonium, after separation from the urine sample, is electrodeposited on a metal disk. The disk is held against a nuclear-track emulsion for 168 hr. The nuclear track emulsion chosen was Kodak NTA emulsion 25 m thick on 1 x 3-in microslides. After emulsion development, tracks are counted under a microscope. Optimum developing time, without agitation is 6 min in D-19 developer at 68 degrees plus or minus 2 degrees. Drying requires 45 min with agitation and washing, 1 hr.. The microscopic count of tracks is made with dark-fluid illumination and a 4.3 x objective and 10x eyepiece to give a total magnification of 430. A scanning system of counting is employed. The detection limit of less than 0.05 dpm currently achieved on a routine basis is low enough to permit early recognition of low-level plutonium deposition. The particular advantage of the method is that there is virtually no limit to its ultimate sensitivity. By a combination

<293> CONT.
of reducing source size and increasing the exposure time, almost any desired sensitivity should be obtained. Experiments have shown that electrodeposition on 1-mm-dia areas is feasible. Another advantage is the complete freedom from the unpredictable behavior of low-background electronic counters and their higher costs. (FMM)

See also Proceedings of the 2nd United Nations International Symposium on the Peaceful Uses of Atomic Energy held in Geneva, Switzerland, September 1-13, 1958, (p. 144-146), (1958).

<294>
Stover, B.J., F.W. Bruenger, and W. Stevens, University of Utah, College of Medicine, Radiobiology Division, Department of Anatomy, Salt Lake City, UT. 1966, September 30

The Reaction of Plutonium(+4) with the Iron Transport System in Human Blood Serum. COO-119-235; Part of Dougherty, T.F., Research in Radiobiology, Semiannual Report of Work in Progress in the Internal Irradiation Program, (P 76-95), 144 p.

When human blood serum that has been tagged in vitro with monomeric Plutonium(+4) is subjected to gel filtration most of the Pu(+4) is found in two molecular weight ranges, that of the low molecular weight serum proteins and that of small molecules and ions. The distribution of Pu(+4) between the two peaks was variable. In addition a small amount was eluted in the highest molecular weight fraction. By a combination of gel filtration, ion exchange, and electrophoresis the protein in the low molecular weight group that binds Pu(+4) has been isolated and shown to be transferrin, the protein that transports iron. Plutonium(+4) appeared to be bound at the iron binding sites, and the reaction between Pu(+4) and transferrin has been shown to be reversible. The stability constant of the complex was high but less than that of the very stable iron-transferrin complex. The variation in distribution of Pu(+4) between transferrin and the low M.W. region thus is related to the variation in the amount of iron bound by the transferrin. (Auth)

<295>
Testa, C., and G. Santori, Comitato Nazionale per l'Energia Nucleare, Radiotoxicology Laboratory, Occupational Medicine Service, Rome, Italy. 1972

Sensitive Method for the Determination of Low Urinary Plutonium Levels in Occupationally Exposed Workers. Giornale di Fisica Sanitaria e Protezione Centro le Radiazioni, 16(1), 1-6.

The perfection of a sensitive and selective method for the periodic control of occupationally exposed personnel is presented. A litre of urine was used. Batch extraction of Pu(+4) is carried out in a nitric atmosphere with Microtene-710 (a microporous polyethylene) supporting tri-n-octylphosphine oxide (TOPO). Re-elution is obtained by reduction to Pu(+3) with a mixture of hydrochloric and hydroiodic acid. After drying and recovery with sulphuric acid, plutonium is electrodeposited on a steel disk after 5 hr, using $(NH_4)_2SO_4$. The disk is then counted with a solid state detector with a background of about 0.001 cpm. When high values are present, alpha spectrometry can also be carried out. The method gives a yield of 72.5%. Polonium, thorium, neptunium, uranium, protactinium, americium, curium and radium decontamination factors range from 30 to 10,000. Blanks activity (0.07 pCi/24 hr) was in line with the reference value adopted (0.2 pCi/24 hr). By comparison with anionic exchange resin analysis, the new method offers improved thorium and uranium decontamination. It also gives comparable chemical yield in a shorter execution time. (Auth)

<296>
Haghiri, F., Ohio Agricultural Research and Development Center, Department of Agronomy, Wooster, OH. 1972

Decontamination of Soils Containing Fission Products. COO-414-18, Part of Haghiri, F., AEC Final Technical Report for March 1971 to August 1972, (p. 58-66), 67 p.

The method for physical removal of surface contamination after the application of asphalt emulsion on base soil is discussed. Experiments were conducted to examine the effectiveness of several compounds (urea-formaldehyde resin, Dresinol-40 resin, Dresin-205 resin and Vinsalyn-100 emulsion) as agents for embedding soil surface particles and to determine the availability of a given fission product to plants embedded in these compounds. It was shown that Dresincl-40, Dresincl-205 and Vinsalyn-100 Emulsion spray formed a satisfactory soil crust with fine sandy loam, silt loam and silty clay loam soils. The stability of the film increased with increasing concentration of the compounds. The experiment with soil spiked with 0.075 uCi Sr 90 treated with Dresincl 40, Dresinol-205 and Vinsalyn-100 Emulsion; frozen and thawed, and then planted to oats showed that the activity of Sr 90 (Y 90) in plant tissues tended to decrease with increasing concentration of both Dresincl-40 and Dresinol-205) uptake by the oat plants was reduced as high as 56% with Dresincl-205. Although the activity of Sr 90 (Y 90) in cat plants due to Vinsalyn-100 was depressed, different concentrations of this compound had no apparent effect. It appeared that the compounds did not embed the surface soil particles completely, or if the particles were embedded the embedding film eventually became unstable under freezing and thawing conditions resulting in separation of contaminated soil particles from the embedding film. (FMM)

<297>
Langham, W.H., Los Alamos Scientific Laboratory, Health Division, Los Alamos, NM. 1947, August 14

Determination of Plutonium in Human Urine. MDDC-1555; LA-DC-435; 10 p.

A detailed account is given of the collection, ashing, and analysis of a 24-hour urine sample for plutonium. This is an account of the method currently in use at the Los Alamos Laboratories for the diagnosis of exposure of personnel to plutonium. The statistical method for evaluating results is also given. (Auth)

<298>
Keller, C., University of Karlsruhe, Karlsruhe, German Federal Republic. 1973, May

Chemical, Nuclear, and Biological Properties of the Transuranium Elements. Naturwissenschaftliche Rundschau, 2695), 191-204.(German)

<298>

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<298> CONT.
A detailed review is given of the chemical and nuclear properties, the biology and the handling cf transuranics with comparisons to other elements of the periodic table. The behavior of the transuranics is largely determined by external, ncn-element specific influences such as radioactive decay, release of heat and radiation. Pecularities such as microscale availability and short half-life have led to new experimental techniques in the separation of the transuranics. (RAF)

<299>
Baturin, G.N., Not given. 1972, November 1

Ratios of the Average Concentrations of Uranium and Organic Matter in Recent Sea and Ocean Sediments. Doklady Akademii Nauk SSSR, 207(1), 186-189.(Russian)

Values of the ratio u/c organic were obtained on recent sediments of the major seas and oceans of the earth. Two classes were recognized: "background" U content (<5 x 10(E-4)%)) and higher (>5 x 10(E-4)%)). A relative uniformity of U/C (organic) among the samples tested indicated that on the whole the possibilities of accumulation of hydrogenic U in the organic components of the sediments were limited. (KSW)

<300>
Carnahan, C.L., and P.R. Fenske, Teledyne Isotopes, Las Vegas, NV. 1971, August

Digital Computer Simulation of Water Table. NVO-1229-173; 41 p.

Initial stages of development of a digital-computer method for simulation of water tables have been completed. The method may be used in regions where hydrologic data is sparse. A topographic surface, represented by a matrix of elevation values, was smoothed, raised or lowered in altitude, and compressed or expanded in amplitude, to provide a first approximation to the water table. The first approximation was then fitted to observed water elevations at preselected control points. This adjustment produced exact fitting at control points; nodes which do not correspond to control points were adjusted by amounts dependent on distance from all control points. The method was applied to the Hot Creek Valley and Pahute Mesa areas in Nevada. Possible deficiencies of the method requiring further development included lack of adequate means for verifying or correcting a computed water table by use of hydrologic data at off-matrix points, and lack of means for matching computed elevations along boundaries between adjacent matrices. Computer program functions are described and code listings are given. (Auth)

<301>
Cherdyntsev, V.V., and J. Schmorak (Translator), Geological Institute of the Academy of Sciences of the USSR, Dating Laboratory, Moscow, USSR. 1971

Uranium 234 in the Ocean. Part of Cherdyntsev, V.V., Uranium 234, Chapter 7. Keter Press, Jerusalem, Israel, (p. 177-234), 234 p.

A review is given of U in seawater corals, mollusk shells, and deep sea deposits. Studies were made on the isotope composition of U in 20 specimens of water from the Pacific, Indian, and Atlantic Oceans, the Mediterranean and the Red Sea, sampled both at the surface and at depths up to 5,000 meters. The gamma-value (U 234/U 238 activity units) varies between 1.13 and 1.17. Corals and mollusks shells displayed the same uranium isotope ratio as the seawater, since they use seawater to build up their skeletons. One study showed that the gamma value of seawater increased with depth, the minimum value occurring at 2 kilometers depth which corresponds to the minimum oxygen content. The average content of U in fluid waters of the world is unknown but is probably not less than 1.10(E-7) g/l. By estimating the time taken for river water to fill the ocean basin, it is suggested that 1,500,000 years is the maximum time for the existence of U in seawater. The ocean contains about 5 billion tons of U of which dozens of thousands of tons escape every year. The content of Th and also of Ionium and protactinum in ocean water have also been determined. The dating of corals and mollusks shells is discussed with mention made of the use in level of the seas as a result of deglaciation which followed the main quaternary glaciation. Studies on benthic deposits show that they do not contain excess amounts of U 234 and in most cases are even deficient with respect to the equilibrium value. The gamma values varied between 0.78 and 1.07 with gamma = 0.93 as the average value. The sea oozes however are remarkable for their very high Th/U ratio; these may be as high as 10 in isolated cases while the average value is 5.1. The average content of U in oozes is quite high--2 x 10(E-6) to 3 x 10(E-6) g/g and the uranium leached out of the ooze may act as an important source of supply of U to the sea water. The U cycle in the sea may be roughly represented as follows: elements enter the sea with river waters, both as true solution with colloidal particles or as matter absorbed on these particles. They then form deep water deposits. The U which is then leached out of these particle again becomes only dissolved in water in the form of orange salts. (FMM)

Table 72 shows isotopic ratio of U, Th and Ra in benthic deposits of the world ocean. This is a translation of Report, URAN-234.

<302>
Cowan, M., Jr., Sandia Corporation, Albuquerque, NM. 1960, November

Plutonium Contamination from One-Point Detonation of an XW-25 (U). WT-1510; 113 p. (Secret)

<303>
Eisenbud, M., New York University, New York, NY. 1968

Radionuclides in the Environment. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 3-18), 680 p.

Twenty-five years of experience in the atomic energy industry has shown that radioactive substances can be handled safely. Traces of fission and activation products can be detected in the environment and in some cases in human food and tissues, but the dose from these nuclides is small compared with that received form the naturally occurring radionuclides. Moreover, essentially all of the environmental contamination to date is due to the testing of nuclear weapons; contamination form industrial sources is minimal and is localized near a few large atomic energy facilities. A source of exposure in the future may be from the use of radionuclides like Sr 90, Po 210, and transuranic nuclides such as Pu 238, for use in isotopic power supplies. Millions of curies of Sr 90 are already being separated for use in small power supplies that will operate weather stations in remote areas, in Coast Guard beacons and in deep-sea recording devices. Thousands of curies of

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<303> CONT.
radionuclides are also being used in SNAP devices aboard satellites in outer space. One such unit containing 17,000 curies Pu 238 has re-entered the atmosphere prematurely and has presumably burned up and become dispersed in the upper atmosphere from which it is descending in a new kind of fallout. The potential use of thermonuclear explosions for peaceful purposes is considered. There is a great deal of enthusiasm about the Plowshare Program as evidenced by the consideration being given to the construction of a second Panama Canal with nuclear explosives. There is ample evidence that modern technology is more than adequate to deal with the potential risks of radioactive materials, and that the minimal amounts of radioactive contamination that results from the use of nuclear reactors and other civilain applications of atomic energy involve negligible risks for which in return, there are tangible benefits. Perhaps the greatest benefit from the use of the nuclear power is that as a substitute for fossil fuels; it helps to reduce air pollution. (Auth)

<304>
Emery, R.M., and T.P. Garland, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1974, December

The Ecological Behavior of Plutonium and Americium in a Freshwater Ecosystem: Phase 2, Implications of Differences in Transuranic Isotopic Ratios. BNWL-1950 (Part 2); Part of Vaughan, B.E., et al, Annual Report for 1974, (p. 99-100), 238 p.

The ecological behavior of Pu and Am in a freshwater processing wastewater pond has been studied to characterize the pond's limnology and define the isotopic distributions in the ecosystem. Results from the study show that the history of transuranics discharged to the pond has created a complex combination of source terms and isotopic ratios. Very large quantities of U 238, approximately 1400 kg, have been discharged into waste trenches leading to the pond. With regard to transuranic isotopes, some unusually high ratios occur in the pond. The ratios of Pu 238 to Pu 239, Pu 240 and Am 241 to Pu 239, 240 occurring in the pond biota, are significantly higher than those in the sediments. A common source of "available" Pu and Am for pond biota is suggested by the rapid establishment of Pu 238 to 239, Pu 240, and Am 241 to Pu 239, 240, ratios in goldfish (CARASSIUS) which were experimentally introduced into the pond. Within 2 weeks after these fish had been introduced into the pond they had accumulated transuranic ratios which were similar to those of other pond biota and dissimilar to those of the pond sediment. Considering the rapid exchange rate of water in the pond and implications of the transuranic ratios occurring in the pond's ecosystem, it is possible that the source of Pu and Am which is "available" to the biota is not the pond sediments, but the sediments of a trench which supplies the pond with wastewater from Pu processing operations. (FMM)

See also BNWL-1879, 26 p. (December, 1974).

<305>
Emery, R.M., D.C. Klopfer, and W.C. Weimer, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1974, December

The Ecological Behavior of Plutonium and Americium in a Freshwater Ecosystem: Phase 1, Limnological Characterization and Isotopic Distribution. BNWL-1950 (Part 2); Part of Vaughan, B.E., et al, Annual Report for 1974, (p. 96-99), 238 p.

A study concerned with the ecological behavior of Pu and Am is being carried out in a shallow waste pond (14 acres) which has existed and received Pu processing wastes for about 30 years. The system is ultra-eutrophic and the major organisms are macrophytes (mainly POTAMOGETON), algae (mainly CLADOPHORA), benthic invertebrates (mainly dipteran and odonate larvae, hemipterans, amphipods, and gastropods) and goldfish. Sediments are the principal repository of Pu and Am containing about 390 pCi of Pu 238, 239, 240 (sigma Pu)/g (dry) and about 83 pCi of Am 241/g. POnd water had much lower concentrations of sigma Pu (0.01 pCi/l) and Am 241 (1.1 pCi/l). In the biota the principal concentrator of Pu and Am is decomposing algal material, the major feeding substrate for the system, containing about 2 nCi for Pu/g and 250 pCi of Am 241/g. Watercress (RORIPPA) has relatively high concentrations of sigma Pu and Am 241 (532 and 125 pCi/g respectively). Ratios of Pu 238 to Pu 239, 240 in the pond biota are generally higher than those of the sediments (0.9). It appears that most of the pond organisms, flora and fauna alike, are selecting Pu 238 slightly over Pu 239, 240. Plant material having the highest accumulation of Pu had ratios ranging from 1.3 to 1.6. Only goldfish muscle tissue had a ratio favoring 239, 240 Pu. The ratio of Pu 238 to 239, 240 Pu in the pond water is 3.5, which may be reflected in the relatively high ratios of biota. Algal floc and emerging chironomids were the only biological components with ratios of Am 241 lower than that of the sediments (0.13:1). Watercress had an Am 241 to sigma Pu ratio equal to that of the sediments (0.23), while the remaining biota sampled had Am 241 to sigma ratios ranging from 0.4 to 2.0. (Auth) (FMM)

See also BNWL-1867, 77 p., (September, 1974).

<306>
Hardy, E.P., Jr., Health and Safety Laboratory, Environmental Studies Division, New York, NY. 1974, October 1

Depth Distribution of Global Fallout Strontium 90, Cesium 137, and Plutonium 239, 240 in Sandy Loam Soil. HASL-286; Part of Hardy, E.P., Jr., Fallout Program Quarterly Summary Report, June 1, 1974 through September 1, 1974, (p. I-2 - I-10), 169 p.

The objective of this study was to measure the depth distributions of Sr 90, Cs 137, and Pu 239, 240 on a biannual basis to estimate the rate of movement. The first of a series of depth profile samples taken at an undisturbed site on Cape Cod have been analyzed for these isotopes. Cesium 137 showed the least tendency to migrate downward followed by Pu 239, 240 and Sr 90. (Auth)

<307>
Jordan, C.F., M.L. Stewart, and J.R. Kline, Argonne National Laboratory, Radiological and Environmental Research Division, Argonne, IL. 1974, July

Tritium Movement in Soils: The Importance of Exchange and High Initial Dispersion. Health Physics, 27, 37-43.

<307> CONT.
Results of a field experiment to determine tritium measurement through soil were compared with several predictions made by a mathematical model. The input parameters of the model were evapotranspiration, soil water diffusion, gravity flow and the past 48 hr history of rain. Initial predictions of the quantity of tritium in soil as a function of time were about an order of magnitude too low. The fit was greatly improved when tritium exchange with hydrogen on soil particles and a high initial dispersion through large soil pores were incorporated into the model. (Auth)

<308>
Jorgensen, C.D., Brigham Young University, Provo, Utah. 1970

Free Living Mites of the Nevada Test Site, Final Report. COO-1731-4, 47 p.

The importance of determining the effects of nuclear weapons testing on phytophagous mite distribution and composition and to examine what free living mites are present at the Nevada Test Site is apparent if nuclear energy is considered a tactical weapon. Objectives of the study were to examine two population responses (species diversity and trophic organization) of desert mites, under field conditions, to ionizing radiation and particularly beta radiation. Five sampling sites northwest and northeast of Project Cabriolet Ground Zero were designated, and the source of radiation was the fallout cloud from Cabriolet. Seventeen phenotypically distinct groups of mites were identified. Diversity indices and trophic level organization for each site is presented for June 1968 through September 1969. The major form of radiation was beta, but no attempt was made to partition the effects of gamma and beta. Results suggest that species diversity tended to increase or remain stable when subjected to radiation stress. Analysis of trophic level organization agreed generally with other findings that the predator-prey ratio decreased with stress and that a mite predator was more sensitive to radiation stress than the mite prey. However, two of the sites did not conform to predicted results. More study must be made of the apparently unpredictable and often extreme variations in distribution patterns of groups and the biology of the groups. Taxonomical lists of plant species and faunal sampling are included. (BBM)

<309>
Koranda, J.J., and J.R. Martin, Lawrence Livermore Laboratory, Biomedical Division, Livermore, CA. 1971; 1972, July 13

The Movement of Tritium in Ecological Systems. CONF-710809 UCRL-73178 (Rev. 1); Part of Moghissi, A.A. and Carter, M.W. (Eds.), Proceedings of a Symposium on Tritium held in Las Vegas, Nevada, August 30-September 2, 1971. Messenger Graphics, Publishers, Las Vegas, Nevada, (p. 430-455), 807 p.

Tritium movement in ecological systems is complex and involves many compartments, both physical and biological. The uptake of tritiated water and vapor occurs rapidly in plants and animals, but because of the rapid turnover of body or tissue-water in living organisms, the half-times are generally short. Plant half-times may be measured in minutes or hours, while animal body-water half-times are one to two days to 15 days. In plants, organic fixation of tritium occurs even in exposures of short duration and the half-time of tissue-bound tritium is considerably longer than that in tissue-water. Tritium movement in soils is affected by soil characteristics such as bulk density and the displacement of the tritium pulse within the soil system by subsequent increments of rain or irrigational water. Intermediate to long half-times are observed in soil systems with the major factors affecting loss rates being porosity and rainfall rate. In well-drained, porous soils, vapor losses may be effective in dissipating tritium pulses while in denser soils with higher rainfall rates, leaching of soil water is the dominant factor. The half-time of tritium in plants growing on tritium-contaminated soil is extended by the longer half-time in the soil. The root zone of the plant will contain tritium for varying lengths of time depending upon rainfall rate and soil characteristics. The following summary statement concerning the movement of tritium in ecological systems may be made: The behavior of tritium in soil systems exhibits a rapid, initial loss with the remaining activity decaying with intermediate to long half-times, the half-time of tritium in the shoil system will determine the effect of the exposure on the rest of the ecological system. The behavior of tritium in plants is similar for vapor or liquid exposures with a large fraction of the deposited activity being lost in a short-lived component of the half-life decay. The behavior of tritium in ecological systems will vary with the flux of water through the system and the rate of biosynthesis. Half-times in agricultural systems will be short, but high rates of incorporation will occur. (Auth)

<310>
Miyake, Y., Y. Sugimura, and E. Matsumoto, Meteorological Research Institute, Koenji-Kita, Suginami, Tokyo, Japan, Tokyo Kyoiku University, Ohtsuka, Bunkyo, Tokyo, Japan. 1968, March

Ionium-Thorium Chronology of the Japan Sea Cores. Records of Oceanographic Works in Japan, 9(2), 189-195.

The rate of deposition of two cores collected at the depth of about 3,000 m in the central part of the Japan Sea Basin was studied by means of the ionium-thorium method. Results showed the rate of deposition of 14.5mm/10(E+3) y for the core #64-19 and 15.8 mm/10(E+3) y for the core #64-21, repsectively. Uranium content in the surface layer was about 3 ppm. An abrupt increase in uranium content was found below 15 cm-20 cm from the surface which continues to the bottom of the core of 1 m long. This may be related to the great sea level change during the last glacial period. (Auth)

Table 1 shows activity ratios of Th 230/Th 232 and Th 228/Th 232 and total amounts of Th and U in Seifu core #64-19 in the Japan Sea. Table 3 shows total amounts of U and activity ratios of U 234/U 238 and Th 230/U 234 in Seifu core #64-21.

<311>
Miyake, Y., Y. Sugimura, and K. Saruhashi, Meteorological Research Institute, Koenji-Kita, Suginami, Tokyo, Japan. 1973, March

Content of Plutonium in River Water in Japan. Papers in Meteorology and Geophysics, 24(1), 75-78.

<311>

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<311> CONT.
The content of plutonium in the water of eight main rivers in Japan was determined. The average value of the total content of plutonium is 1.4 x 10(E-3) pCi/l in which 0.4 x 10(E-3) pCi/l is contained in the suspended matter. The annual run-off plutonium is only 0.12% of the accumulated plutonium on land. This suggests that the fallout plutonium is adsorbed on soil surface firmly and it is difficult to be leached out. (Auth)

Table 1 shows the results of analyses of Pu 239, 240 in Japanese rivers.

<312>
Randerson, D., and J.S. Cornett, National Oceanic and Atmospheric Administration, Air Resources Laboratories, Las Vegas, NV. 1973, May

Numerical Prediction of the Mesoscale Transport of Atmosphere Effluents: Philosophy and Morphology of Experimental Models for Predicting the Wind and Potential Radiological Fields over the Nevada Test Site. NOAA-TM-ERL-ARL-37; APLV-351-28; 56 p.

Two experimental numerical models are described and tentatively verified. One model predicts the mesoscale wind field over mountainous terrain and the other model forecasts the temporal and spatial changes in the airborne radioactivity field that might be associated with an accidental release of debris during nuclear testing on the Nevada Test Site. A mesoscale wind-prediction model is derived from the assumption of the conservation of vertical wind shear for a time period of at least 6 hr. over an area 160 x 160 n mi. This assumption is closely analogous to the conservation of horizontal vorticity. Verification of the wind-prediction model is accomplished through two different modes. First, 10 independent cases of different wind regimes are used to verify the wind predictions for three different stations. The average root-mean-square error in speed for these stations varies from 6.2 kt for a 1-hr prediction to 9.8 kt for a 6-hr prediction. Second, for 20 different independent cases, comparisons against persistence forecasts and wind-ladder forecasts, prepared by the duty forecaster for Yucca Flat, showed that the model did as well as both for a 2-hr prediction and better than both for a 6-hr prediction. The radiological-prediction model is difficult to verify, but preliminary results look realistic. In the single case used to verify the radiological forecasts, the model predicts the path of the debris cloud to be too far east by about 13 n mi, 2 hr after detonation, and by about 20 n mi, 3 hr after detonation. Above the 7000-ft level, the speed of movement of the cloud center is too fast by about 10 to 15 kt for a 3.5 hr. forecast. The 7000-ft trajectory compares reasonably well with the estimated cloud positions reported by pilots, the predicted cloud-center trajectory being within about 8 n mi of the estimated cloud centroid throughout the duration of a 4-hr forecast. Predicted cloud-center W 187-activity values are about an order of magnitude too large; however, it is not known if the aerial-sampling data used in this verification were taken in or near the region of maximum activity beyond 0.5 hr after detonation. (Auth)

<313>
Robertson, D.C., Battelle Memorial Institute, Pacific Northwest Laboratories, Radiological Sciences Department, Richland, WA. 1971, September 8; 1972

Influence of the Physico-Chemical Forms of Radionuclides and Stable Trace Elements in Seawater in Relation to Uptake by the Marine Biosphere. BNWL-SA-4048; CONF-710988; Part of Proceedings of a Symposium on Marine Radiocecology held in Hamburg, Germany, September 20-24, 1971, (p. 21-93), 214 p.

In laboratory experiments and in actual field studies gross differences in the biological uptake between radionuclides and their stable isotopes from seawater have been observed and attributed to differences in physico-chemical form. These forms are usually classified into three categories, namely, species in true solution, colloidal speices and particulate forms. The most important radionuclides entering the marine environment are those with relatively long half lives and the ability to be rapidly and efficiently taken up and retained by the marine biosphere. Neutron activation products of biologically essential transition elements are frequently accumulated to a very high degree by the biosphere. The most predominant activation products which have been observed in fallout and effluents from nuclear power reactors include Fe 55, Zn 65, Co 60 and Mn 54. These elements are accumulated from seawater by factors ranging from 10(E+3) to 10(E+5). Case studies of the influence of physico-chemical forms of radionuclides in relation to biolcgical uptake are presented for Fe 55, Zn 65, Ru 106 and Pu 239. Pu 239 concentrations in ocean surface waters range from 0.11-3.0 x 10(E-5) Ci/kg (1.8-48 X 10(E-15) g/kg). The concentrations of Pu 239 in marine organisms vary widely. Pu serves no useful function in the biochemistry of marine organisms and is co-accumulated by ingestion of food, water or sediments or is adsorbed on the outer surfaces of organisms. It appears that the majority of the plutonium present in the oceans is available for biological assimilation mainly in a particulate form. For seaweeds and certain crustaceans, the relatively high accumulation of plutonium appears to be a surface adsorption process. This relatively high accumulation of plutonium by seaweeds suggests that the critical pathway for Pu 239 from the ocean to man might be by consuming edible seaweed products. Areas of needed research on the distribution and behavior of various forms of oceanic constituents are discussed. (FMM)

Table 15 shows Pu 239 concentration in marine organisms including fish, plankton, clam and starfish.

<314>
Silker, W.B., Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1974, December

Plutonium Concentrations in the Pacific Ocean. BNWL-1950 (Part 2); Part of Vaughan, B.E., et al, Annual Report for 1974, (p. 134), 238 p.

A library of samples collected from many parts of the world's oceans is available for measurement of the temporal and spatial distribution of Pu isotopes. Measurements on vertical profile samples collected in1968 at 41 degrees N, 143 degrees W in the North Pacific Ocean revealed Pu 239 concentrations of 0.72 dpm/m3 in the mixed surface layer, decreasing to 0.31 to 0.42 dpm/m3 within the thermocline to a depth of 100 m. Analysis of selected suface samples collected on a 1971

<314> CONT.
cruise from Seattle to Samoa showed Pu 239 concentrations which averaged 0.30 dpm/m(3) in the 30 degrees to 45 degrees N latitude band, increased to 1.0 dpm/m(3) at 20 degrees N and then decreased to 0.52 to 0.67 dpm/m (3) at the equator. The 239, 240/238 Pu ratios in the NOrthern Hemisphere were 0.11 plus or minus 0.1, and increased to nearly 0.3 south of the equator, reflecting the introduction of Pu 238 to the Southern Hemsphere by failure of SNAP-9A. In the same year, samples were collected along the eastern boundary of the Pacific Ocean. From the equator to 10 degrees S, the 239 Pu concentrations averaged 0.18 dpm/m(3) and north of the equator the concentration was quite constant, averaging 0.31 dpm/m(3). This is interesting from two standpoints. First, no concentration maximum was observed in the 8 to 10 degrees N latitude region, where drastically increased concentrations of Be(7) and shorter-lived fission products were seen. Secondly, there was no concertrationgradient with increasing latitude. Both of these conditions indicate that the water mass in this region was well-homogenized as a result of years of advective and diffusive processes existent within the oceans. (FMM)

<315>
Koranda, J.J., J.R. Martin, S.E. Thompson, Jr., M.L. Stuart, D.R. McIntyre, and G. Potter, Lawrence Livermore Laboratory, Livermore, CA; U.S. Environmental Protection Agency, Las Vegas, NV. 1973, October

Terrestrial Biota Survey. NVO-140 (Vol. 1); Part of Enewetak Radiological Survey, (p. 225-348), 736 p.

The distribution of radionuclides in the terrestrial biota throughout the islands of Enewetak Atoll generally conforms to the results of the environmental radiation survey. On islands with elevated levels or radiation, the biota contained elevated concentrations of radionuclides. The most prominent radionuclides are Cs 137, Sr 90, Fe 55, Co 60, Pu 239, 240. Uptake coefficients are generally very low (about 10(E-3) for Pu 239, 240 in plants, and only occasional concentration effects are seen for Co 60, typically in the livers of animals. The most effectively transferred radionuclide within the terrestrial ecosystems or Enewetak Atoll appears to be Cs 137. Radionuclides such as Co 60 and Fe 55 enter the elemental pools for those elements and are typically found wherever those elements accumulate or sequester in animal tissues. Livers, kidneys, and hepatopancreases are such sites in mammals, birds, and crustacea. Most radionuclide distributions in elements of the terrestrial biota sampled in the survey conform to the classical patterns that have evolved in the development of radiobiological science; e.g., Sr 90, Cs 137, Pu 239, 240 have an affinity for bone, Cs 137 is also found in physiologically active tissues such as muscle, and Fe 55 and Co 60 typically are retained in the liver and kidney. One difficult aspect in the analysis of the data has been the variation in the basic ecological conditions present on the islands surveyed throughout the Atoll. Thus, a concentration factor determined for a species which is colonizing a catastrophically disturbed habitat may be quite different for the same species growing in a stable environment in climatic and edaphic equilibrium. (Auth) (FMM)

Table 59 gives radionuclide concentration levels (K 40, Fe 55, Co 60, Sr 90, Cs 137, Pu 239, 240) for terrestrial biota samples collected at Enewetak Atoll, October 1972-January 1973. Table 76 gives the distribution of radionuclides in terrestrial biota and soils on Alice, Enewetak Atoll, 1972-1973. Similar tables are presented for the other islands.

<316>
Carrard, C., and C. Milet, Commissariat a l'Energie Atomique, Division de Metallurgie et d'Etude des Combustibles Nucleaires, Fontenay-aux-Roses, France. 1973, October

Isotopic Cardiac Pacemaker Safety Tests at 1300 Degrees Centigrade and 800 Degrees Centigrade (Source with Internal Pressure and a Simulated Fuel). CEA-R-4488; 23 p.(French, English Summary)

In accordance with the safety guidelines which are specified by the Nuclear Energy Agency of the O.E.C.D. (Organization for Economic Cooperation and Development) the test program on the entire Laurens Alcatel Medtroni type 9000 cardiac pacemaker has been continued with fire testing (800 C (1472) F) for 30 minutes and 1300 C (2372) F for 30 minutes. In addition to the previous tests, a simulated fuel was used in the source, and the testing was conducted under a pressure inside the inner tantalum capsule, corresponding to the pressure built-up after at least ten years of operation. The first part of the report presents the reasons of the choice of natural uranium for the simulated fuel; in the second and third parts respectively, the results of the testing at 800 degrees C and 1300 degrees C are described. In all cases, the tantalum capsules remained fully tight and no outward diffusion of radioactive material was observed. (Auth)

(FR)Stimulateur Cardiaque Radioisotopique Essais de Securite a 1300 C et a 800 C Source Avec Pression INternect Combustible Factice

<317>
Doran, W.T., U.S. Atomic Energy Commission, Washington, DC. 1968

Magnitude of Deposited Radionuclide Problem Based on Future Usage--Civilian Aspects. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 471-481), 680 p.

The future uses of the increased production of radionuclides can be categorized as follows: 1) source of heat and power, 2) medical diagnostic and therapeutic applications, 3) improvements in general technology including industrial and agricultural, and 4) new applications in scientific research. The growth of reactors in size and number is reviewed, also the amounts and usage of radioisotopes produced by the reactors. The use of radioisotopes as a source of heat and electricity is discussed in relation to space vehicles, weather prediction, navigation and communications satellites. The properties of isotopes important for power sources are presented. About 30 isotopes are promising for power sources are presented. About 30 isotopes are promising as fuel. Nine of these have physical properties and potential costs which make them attractive. Of the nine practical radioisotope fuels, the four beta-gamma emitters (Sr 90, Cs 137, Ce 144 and Pm 147) are fission products that are recovered from nuclear fuel reprocessing plants. A fifth beta-gamma emitter, Tm 170, is made by irradiation of a stable isotopic target in a nuclear reactor. The other four are all alpha emitters: Po 210, Pu 238, Cm 242 and Cm 244, and are made artificially in nuclear reactors. Po 210 is currently the preferred fuel for short-lived space power systems. For long-lived space systems, Pu 238 is the preferred fuel. For long-lived terrestrial missions, Sr 90 and Co 60 appear to be best, except in some specialized low-power systems wherein the higher cost of Pu 238 must be afforded. The diagnostic applications of radionuclides are presented in tabular form, also the thirty-two gamma or positron-emitting and seven beta-emitting radionuclides in medical use are listed. The health and safety problem was also discussed.

<318>
Mullins, L.J., G.M. Matlock, J. Bubernak, and J.A. Leary, Los Alamos Scientific Laboratory, Los Alamos, NM. 1972

Characterization and Properties of Medical-Grad Plutonium 238 Fuels. CONF-720519; Part of Proceedings of the 2nd International Symposium on Power from Radioisotopes held in Madrid, Spain, May 29-June 1, 1972, (p. 49-67), 986 p.

The Pu 238 requirements, 55-90 g for an artifical heart or circulatory assist device demand a fuel having minimal radiation properties. The preparation and evaluation of potential Pu 238 fuel forms at the Los Alamos Scientific Laboratory has led to the development of four fuel compositions, electrorefined metal, Pu 238-3at. %Ga, Pu 238 N, and Pu 238 PuO2. The latter 3 fuels are made from electrorefined metal. Theoretical and experimental studies of these fuels led to the conclusion that Pu 238 PuO2 is the preferred composition for high temperature application in the artificial heart program. This fuel is prepared as a pressed and sintered oxide. Procedures have been developed for preparing and characterizing cylindrial oxide sources varying in size from one to fifty watts. (Auth)

<319>
Tedford, C.F., Bureau of Medicine and Surgery, Washington, DC. 1968

Magnitude of Deposited Radionuclide Problem Based on Future Usage--Defense Aspects. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 482-486), 680 p.

The Navy's interest and use of nuclear energy dates back many years to 1939 when it was the first governmental agency to expend money on nuclear fission. During the 23 ensuing years the Navy has become one of the largest users of nuclear energy within the United States. Nuclear energy is widely used within the Navy for nuclear propulsion, medical diagnostic and therapeutic purposes, research application and in nuclear weapons. Nuclear warheads have posed problems with respect to radiation safety in the past. However, it should be emphasized that the number of serious accidents that have occurred are very few in number. The most recent and widely publicized incident occurred on January 17 1966 when a B52 bomber collided with a KC-135 Tanker aircraft during refueling operations near Spanish territory (Department of the Air Force, 1966). The resulting impact permitted the uncontrolled dispersion of four nuclear weapons three of which fell on Spanish soil and one in the Mediterranean Sea. The location of the fourth weapond remained a speculative matter for about three months. A large-scale operation continued on land and

<319> CONT.
sea until March 26, 1966 when it was removed from the sea. Precautions were taken to prevent gross exposures to plutonium. The contaminated areas were monitored with PAC-1's alpha survey meters. Before completion of the task, several tons of topsoil were collected, sealed in barrels and removed to a burial ground in the United States. Accidents of this nature are the exception rather than the rule. To maintain a proper defense posture, certain calculated risks must be borne. (Auth)

<320>

ENVIRONMENTAL ASSESSMENT

<320>
Bethlendy, G., Not given. 1973

Environmental Aspects of Nuclear Power Stations. Environmental Letters, 4(3), 151-185.

The radioactivity to which we are exposed as a result of the development of nuclear power is a minute proportion of the total that we receive from nature and from diagnostic and therapeutic x-rays. The world's need for energy will quadruple in the next thirty years and for compelling reasons a growing share of the total will be provided by nuclear energy. The rapid growth in nuclear power production will inevitably increase the amount of radioactive wastes that must be managed in a way which avoids environmental pollution. The technology of waste management is well developed and this could be done. Nuclear energy, far from being a major contributor to the pollution of the environment, will in fact diminish pollution as it replaces other sources of electric power such as coal and oil. Nevertheless, particular attention must be, and is being, given to a number of problems such as the thermal effects of nuclear power plants; the improvement of the technology and economics of containment techniques for reactors and radioactive waste; decommissioning of old nuclear power plants; and the behavior of radioactive materials in water and aquatic organisms. The techniques developed to ensure the safety of the nuclear industry might be profitably studied by other industries. (Auth)

<321>
Cowart, J.B., and J.K. Osmond, Florida State University, Tallahassee, FA. 1974

Uranium 234 and Uranium 238 in the Carrizo Sandstone Aquifer of South Texas. CONF-740312; STI/PUB/377; IAEA-SM-182/35; Part of Proceedings of a Symposium on Isotope Techniques in Groundwater Hydrology held in Vienna, Austria, March 11-15, 1974, Vol. 2, (p. 131-149), 499 p.

The waters of the Carrizo Sand formation of South Texas, United States of America, exhibit a pattern of uranium isotopic disequilibrium described in terms of U 234/U 238 activity ratio ("AR") and uranium concentration, which may be a function of geochemical factors and the hydrologic history of the area. In terms of uranium, two regimes seem to exist. The first, including outcrop and near outcrop sample locations, has waters with relatively high concentration and low AR. Somewhat downdip, the uranium concentration decreases sharply at the downdip limit of the oxidation environment, a zone of uranium precipitation. Recoil of daughter products from the precipitated urarium causes an increase of AR of the water. Water of low uranium concentration and high AR is found throughout the downdip regime. If a constant input of U 234 through time is assumed, the downdip increase in AR after the initial introduction of U 234 into the water may be ascribed to radioactive decay of U 234. However, this assumption leads to the calculation of a water flow rate one twentieth that determined by other means. Alternatively, this pattern may be an artifact of a change of climate from 20,000 years to 10,000 years ago. In this case, the decrease in AR downdip is a function of a varying input of U 234 as well as decay. (Auth)

<322>
Hull, A.P., Brookhaven National Laboratory, Upton, Long Island, NY. 1974

Radioactive Effluent Releases and the Public Acceptance of Nuclear Facility Sites. BNL-19492; CONF-741210; IAEA-SM-188/45; Part of Proceedings of a Symposium on the Siting of Nuclear Facilities held in Vienna, Austria, December 9-13, 1974, (19 p.).

A public controversy about the risks from radioactivity in effluents from U.S. nuclear power plants arose in the late 1960's as their utilization was growing toward large-scale commercial basis. Several scientific critics alleged variously that the existing plants had occasioned excess infant mortality in their vicinities, and that the growth of nuclear power would produce large increases in the cancer death rate in the general population. The controversy occasioned by these allegations led to the BEIR committee review of the effects of exposure to low levels of ionizing radiation. It also appeared to underlie the U.S. AEC's "Appendix I" proposals for numerical design limits for nuclear power plant effluents. These proposals are intended to limit the dose of any nearby individual to 5 mR/yr. This critical review indicates that the critic's allegations were either without substance or irrelevant. Using effluent release data from recent years, the population health risk from power reactor effluent radiation exposures appears to be far smaller than that from fossil-fueled plant effluents, as well as within the range of those otherwise considered as negligible. Such comparisons are suggested as more hopeful toward achieving public acceptance than "as low as practicable measures," which serve to exaggerate the risks of radiation. (Auth)

<323>
Little, C.A., T.F. Winsor, J.A. Regnier, L. Hersloff, and F.W. Whicker, Colorado State University, Department of Radiology and Radiation Biology, Fort Collins, CO. 1974, May 1

Plutonium in the Terrestrial Environs of Rocky Flats. COO-1156-70; Part of Whicker, F.W., et al, 12th Technical Progress Report on Radioecology of Some Natural Organisms and Systems in Colorado, (p. 21-40). 69 p.

The report summarizes experiences during the period May 1, 1973-April 30, 1974 at Rocky Flats with regard to field sampling, sample processing, analytical procedures, biotic inventories, and initial surveys of Plutonium 238, 239 in soil, litter, vegetation and animals. For sampling, smaller areas (macroplots), characteristic of large portions of the site were chosen. Four genera and species, representative of the area were selected, namely western wheatgrass (AGROPYRON SMITHII), cheatgrass (BROMUS sp.), salsify (TRAGOPOGON sp.), and prickly lettuce (LACTUCA SCARIDA). Estimates of mean concentrations of Pu in various ecosystem components are shown in tabular form. The data indicate that soil is by far the largest Pu-bearing component of the ecosystem. In both the highly contaminated and the less contaminated area, soil appears to have greater than 98% of the total Pu for a given square meter. For the less contaminated study area, the contamination appears to be attached mostly to the soil particles in the upper 3 cm, for the highly contaminated study area, over one-half of the total seems to be found between 6 and 15 cm depth, while only

<323> CONT.
about 40% appears in the top 3 cm. The ratio of Pu 239 to Pu 238 in soil as well as in vegetation and small mammals are given. In the highly contaminated macroplot the ratio at the surface is about 61 and decreases to about 38 near 20 cm depth. In the less contaminated macroplot, the ratio is near 40 at the surface and decreases to less than 10. The foliage group has a mean of 21.54 while the root group has a mean of 56.00. It appears that vegetative structures closest to the soil have the Pu isotopic ratio approaching that of soil. The mean ratio values for mammals range from 11.04 for internal tissues of pocket gophers to 41.85 for external tissues of deer mice. Studies are underway concerning soil movement of Pu and the transfer of Pu from soil to vegetation. (FMM)

Table 2.1 shows the vertebrates observed at Rocky Flats (giving class, scientific classification and common name). Table 2.6 shows Pu concentration for various terrestrial ecosystem components (soil, surface litter and detritus) roots,, standing vegetation, arthropods, small mammals) in highly contaminated and less contaminated study areas at Rocky Flats. Table 1.10 shows Pu 239 dpm/g/Pu 238 dpm/g in vegetation from the highly contaminated study area at Rocky Flats. Table 2.9 shows Pu 239/Pu 238 in soils from Rocky Flats.

<324>
Lundgren, D.A., University of Minnesota, Minneapolis, MN. 1973

Mass Distribution of Large Atmospheric Particles. Ph.D. Thesis, University of Minnesota; 161 p. (Dissertation Abstracts, Vol. 34, 5505-B, Order No. 74-10, 537)

The paper describes the results of a study to determine the total mass and the mass distribution of large atmospheric aerosols, especially that mass associated with particles greater than 10 um diameter. This study also determined what fraction of the total aerosol mass a standard high-volume air sampler collects and what fraction and size interval settles out on a dustfall plate. A special aerosol sampling system, designed and built for this study, was used to obtain representative samples of large airborne particles. A suburban sampling site, free of local point sources of aerosols, was selected. Samples were collected under various conditions of wind velocity and direction to obtain measurements on different types of aerosols. Study measurements show that atmospheric particulate matter has a bimodal mass distribution. The large particle mass mode was associated with particles which ranged from an estimated 0.03 to 5 um in size. Combined, these two distributions produced a bimodal mass distribution with a minimum around 5 um diameter. The high-volume air sampler was found to collect most of the total aerosol mass, not just that fraction normally considered associated with suspended particulates. One day dustfall measurements were made but were not able to provide a good or very useful measure of the aerosol mass associated with large particles. The two fundamental processes of aerosol formation, condensation and dispersion, appear to account for the formation of a bimodal mass distribution in both natural and anthropogenic aerosols. Particle size distribution measurements frequently are in error because representative samples of large airborne particles are not obtained. Considering this discrepancy, air pollution regulations should specify or be based upon an upper particle size limit. (Auth)

<325>
Markham, O.D., Idaho Operations Office, Health Services Laboratory, Idaho Falls, ID. 1973, November

National Reactor Testing Station, Environmentally Related Publications. IDO-12078; 11 p.

The bibliography was compiled while reviewing the literature on environmental studies at the National Reactor Testing Station. The list has been restricted to publications resulting from work in the area since the establishment of the site. Progress reports, safety review documents and other similar papers have been excluded. Ninety-six references are given. (Auth) (RAF)

<326>
Mayer, R., J. Jefferis, S. Major, and R.S. Davidson, Battelle Columbus Laboratories, Columbus, OH. 1974, June 30

Bioenvironmental Effects Associated with Nuclear Power Plants, a Selected Bibliography, First Addendum. BMI-X-654; 399 p.

The first addendum bibliography contains selected references collected to assist the U.S. Atomic Energy Commission in acquiring and organizing information to provide bases for general environmental siting guides for nuclear power plants. The index was prepared on Battelle's CDC 6400 computer utilizing a modified Key-Word-Out-of-Context (KWOC) program. Among the topics covered are thermal pollution, thermal effluents, waste disposal, effluents, chlorination, safety, environmental aspects of plutonium, toxicity of power plant chemicals to aquatic life, food webs, plankton and fish populations. (FMM)

<327>
Rodriguez, E.P., Junta de Energia Nuclear, Medicine and Protection Division, Madrid, Spain. 1968

Palomares Two Years After. CONF-680507; Part of Proceedings of a Symposium on Radiological Protection of the Public in a Nuclear Mass Disaster held in Interlaken, Switzerland, May 26-June 1, 1968, (p. 36-38), 688 p.

A continuation of the work carried on at Palomares since the accident is described. One of the efforts is the search for fragments of contaminated material with regard to work on soils. Deep-furrow plowing is recommended in order to produce sufficient renewal in the layers of soil to dilute the radioactive element. Dispersion of the radioactive elements was also achieved by several passes with rotavators under a fine water spray. The problem of decontamination of the sides of the houses was solved by applying several layers of paint. This fixed the contamination so as to prevent resuspension in air, and also absorbed the weakly penetrating alpha radiation. The best form of treatment for contaminated plants was found to be incineration. Here the wind direction and velocity were important so that the smoke would not reach inhabited areas. Sampling has continued. There are four atmospheric dust collecting stations and

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ENVIRONMENTAL ASSESSMENT

<327> CONT.
samples are also taken of soil, water, crop, wild plant life and non-domestic animals. The presence of Pu in the lungs of a group of people, some of whom were exposed at the beginning, and others who were chosen as controls was tested with a whole body counter. Urine samples were also tested for Pu. The results were negative for both the urine analyses and whole body counting. The readings for soils and plants, houses and several locations should be invaluable in facilitating action in the case of a similar accident. (FWM)

<328>
Semonin, R.G., and D.F. Gatz, University of Illinois, Urbana, IL. 1974, April

Study of Rainout of Radioactivity in Illinois. COO-1199-38; Twelfth Progress Report; 21 p.

The field experiments have been continued to estimate convective storm particulate scavenging efficiency in proximity to the St. Louis, Missouri urban-industrial complex. Complimentary studies of the urban aerosol characterization, source strength, and removal processes were also studied. The 1973 field effort produced the following types of samples for analysis and interpretation: 1) 1513 total rain samples from 81 sites; 2) 450 sequential rainwater samples from 3 locations; 3) 266 wet/dry samples from 8 sites; 4) 270 air filter samples from 7 locations; 5) 81 Andersen impactor samples from 3 sites; 6) 14 water samples from aircraft in-cloud and precipitation at cloud base; and 7) 9 air filter samples from aircraft. The analysis procedures require that all water samples undergo filtering for separate analyses of soluble and insoluble fractions of the elemental concentrations. This data collection effort provided 4668 samples for chemical analysis. The status of the analysis of all types of data is described. The preliminary results of an attempt to estimate urban aerosol source coefficients and the source strength of St. Louis are presented. (Auth)

<329>
Soldat, J.K., Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1974, June

Environmental Behavior and Radiation from Iodine 129. BNWL-SA-4879; 21 p.

Recently, attention has been drawn to I 129, a radionuclide which, because of its long half-life (1.6 x 10(E+7) yr), has a potential for long-term accumulation in the environment from low-level chronic releases at nuclear facilities. The transfer of I 129 through the biosphere and the resultant radiation doses to man are discussed. Metabolic parameters are tabulated for four ages 1, 4, 14 and adult. These parameters include fractional uptake via inhalation and ingestion, breathing rate, mass, radius and iodine content of the thyroid size. Factors are presented for calculation of doses from intake or concentration of I 129 in the thyroid. Factors are also derived for estimating thyroid doses from I 129 air concentration via the inhalation, leafy vegetable, milk or meat pathways. Analysis of the atom ratios of I 129/I 127 in the thyroid required to yield a dose rate of 1500 mrem/yr reveals that on this basis the adult thyroid reaches the limiting dose rate at a ratio of 1:48 (3.6 uCi I 129/g iodine). However, a higher ratio of 1:11 (15 uCi/g I) is required for the infant thyroid to receive the same dose rate. The reason for this difference is the higher stable I concentration in the adult thyroid (350 ppm) than in the infant thyroid (90 ppm). In all instances, however, a dose rate of 1500 mrem/yr would result from a concentration of 1.3 x 10(E-3) uCi I 129 per a gram of thyroid. (Auth)

This report is based on work reported in BNWL-1783 (1973).

<330>
Soldat, J.K., D.A. Baker, and J.P. Corley, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1973

Applications of a General Computational Model for Composite Environmental Radiation Doses. IAEA/SM-172/82; STI/PUB/345; CONF-730503; Part of Proceedings of a Symposium on the Environmental Behavior of Radionuclides Released in the Nuclear Industry held in Aix-en-Provence, France, May 14-18, 1973, (19 p.).

A mathematical model for calculation on a large general-purpose digital computer of regional radiation doses resulting from large-scale use of nuclear energy was previously developed and reported. This general model has now been sub-divided to permit rapid calculations for the several exposure pathway groupings in an interactive mode using the BASIC computer language. The sub-programs are completely flexible as to the nuclides, body organs, and pathways for which radiation doses are to be calculated, but include at the present time: 1) Approximately 150 radionuclides, including transuranics, 2) doses to whole body, skin, bone, lungs, thyroid, and gastrointestinal tract, 3) sub-programs for cloud submersion, inhalation of nuclides other than radioiodines (resuspension of deposited nuclides is not included), ingestion of water and aquatic foodstuffs along with external dose from water and sediments, and ingestion of irrigated crops. Thyroid dose from inhalation and ingestion and dose to aquatic biota can also be calculated. Dose factors in the programs for the various media-nuclide-organ combinations have been calculated using ICRP methods. For radionuclides with long effective half-lives, the sub-programs calculate either total dose commitment for a single year's intake or the dose-rate at the end of a specified period of years at constant annual intake. Transfer factors between trophic levels have been taken in most part from summaries published by others, and are updated as newer data becomes available. The major application to date of the compartmented model has been the calculation for the U.S. Atomic Energy Commission of environmental impact statements. Use is also being made of the same model for evaluation of potential radiological impacts associated with the ultimate fate of radioactive wastes for various long-term waste disposal concepts. (Auth)

<331>
Travis, J.R., Los Alamos Scientific Laboratory, Los Alamos, NM. 1974

A Model for Predicting the Redistribution of Particulate Cantaminants from Soil Surfaces. LA-UR-74-1340; CONF-740921; Part of Proceedings of the Atmospheric-Surface Exchange of

<331> CONT.
Particulate and Gaseous Pollutants Symposium held in Richland, Washington, September 4-6, 1974, (58 p.).

A computerized model was developed to describe the redistribution of wind eroding soil-contaminant mixtures. Potentially mobil particulate contaminants can, in the first approximation, be assumed to be indistinguisnable from the wind eroding soil in which they are distributed. A grid network characterized important soil and surface conditions, and mass conserving control volumes are constructed on each cell. Material is transported through the vertical and top surfaces of a control volume by a modified Pagnold-Chepil horizontal flux formulation and molified Gillette vertical flux formulation, respectively. The vertical emissions, considered as puffs from area sources, create at regular time intervals a contaminant cloud which is proportional to the suspendable ground concentration. These puffs diffuse downwind under time dependent wind velocity and atmospheric stability conditions, maintaining during the time interval a three-dimensional Gaussian distribution of concentration with cloud volume. Material from each puff is deposited in downwind cells, leading to the possibility of many different flights from these new sources. The usefulness of the predictive tool is demonstrated by calculations involving mixtures of particulate Pu 238 PuO2 in highly erodable soils under dust storm conditions. Time dependent surface concentration and breathing zone exposure isopleths, evolving from a small contaminated area, show the potential hazard from wind eroding toxic materials. (Auth)

<332>
Weksnal, E., and F. Yaron, Hebrew University of Jerusalem, School of Applied Science and Technology, Groundwater Research Center, Jerusalem, Israel; Israel Atomic Energy Commission, Nuclear Research Center, Weger, Israel. 1974

Uranium 234/Uranium 238 Disequilibrium in Waters of the Judea Group (Cenomanian-Turonian) Aquifer in Galilee, Northern Israel. CONF-740312; SM/PUB/373; IAEA-SM-182/34; Part of Proceedings of a Symposium on Isotope Techniques in Groundwater Hydrology held in Vienna, Austria, March 11-15, 1974, Vol. 2, (p. 151-177), 499 p.

Analysis of U 234/U 238 activity ratios and uranium concentrations were carried out on samples from 60 water sources of the Judea Group (Cenomanina-Turonian) carbonate aquifer of Galilee, northern Israel. The U 234/U 238 activity ratios were found to vary from from 1.04 to 2.81, and successive analyses of selected water sources show that values from the same sampling sites remained consistent over a three-year period (1970-73). The recorded values of the U 234/U 238 activity ratio may be grouped into three main clusters clearly related to the paleohydrological evolution of the area under consideration: (a) Low U 234/U 238 activity ratios ranging from 1.04 to 1.72 (the majority not exceeding 1.55) were reported from the water sources of western Upper Galilee. This area is drained into the Mediterranean, and its meteoric groundwater circulation regime is as old as the Neogene. (b) Intermediate U 234/U 238 acitivity ratios (1.65-1.93) are common among the water sources of the Pleistocene Jordan Rift Valley catchment area. (c) Higher U 234/U 238 acitvity ratios, ranging in general from 1.9 to 2.8, were found in the water sources of the Lower Galilee, where there has been renewed active groundwater circulation both eastward and westward caused by the latest subsidence of the Jordan Rift Valley and the Mediterranean Young Pleistocene Sea Regression. These results point to the possibility that the mechanism of uranium isotope fractionation within this type of aquifer is basically governed by the solid rock-freshwater flow contact history. Further information gained by such studies might be useful in developing a better hydrogeological model for the groundwater flow regime within carbonate aquifers. (Auth)

<333>
Kornberg, H.A., Hanford Atomic Products Operation, Richland, WA. 1958, Janaury 10

Hanford Biology Research Annual Report for 1957. HW-53500; 226 p.

This annual summary of the research activities of the Hanford Biology Operation contains studies on the uptake, distribution and turnover of radioelements in plants, animals, and communities; the biological effects of ionizing radiation on certain organs and organisms; and the effects of operations at Hanford on its plant and animal life. Individual reports deal with factors that affect radiostrontium uptake and deposition in plants and animals, the assessment of fallout hazards of Cs 137, and I 131 uptake by plants and animals including biological effects of I 131 in large animals. Plutonium studies reported range from validating administration techniques and measuring distribution and turnover of Pu to testing agents for its removal from the animal body. Small and large animals and soluble and insoluble forms of Pu were used. Papers dealing with radiation hazards include a discussion of the turnover and removal of radioactive particles and pulmonary malignancies caused by them. Also given are some aspects of the fundamental mechanisms by which ionizing radiations cause biological effects. The last section deals with measuring concentrations of reactor effluent radioelements by bio-accumulation, the absorption and turnover of Zn 65, the effects of chromium on heat on fish and the population density of fish in the vicinity of Hanford. Ten articles were abstracted separately for the data base. (RAF)

<334>
Porch, W.M., Lawrence Livermore Laboratory, Livermore, CA. 1974

Fast-Response Light Scattering Measurements of Aerosol Suspension in a Desert Area. Atmospheric Environment, 8, 897-904.

Observations with a specially developed fast-response instrument for light scattering measurements show that aerosol suspension and resuspension by diurnal winds in desert areas occur in relatively concentrated puffs of dust of short duration (less than or about 2 min.). The frequency of these puffs appears to be related to the meterological conditions of the area. On chance occasions dust devils were observed by the instrumentation, exhibiting aerosol characteristics appreciably different from those of diurnal wind-suspended particulates. (Auth)

<335>

INSTRUMENTATION

<335>
Armstrong, F.E., Bartlesville Energy Research Center, Bartlesville, OK. 1974

Coal Mine Dust Incombustibles Content Analyzer Using a Gamma-Ray Backscatter Technique. BUMINES-RI-7946; 10 p.

An instrument using a gamma-ray backscatter technique for determining the weight-percent incombustibles content of coal dust and rock dust mixtures in coal mines has been built and tested. The unit gives a direct readout in percent incombustibles for coal mine dust mixtures containing between 50 and 100 percent incombustibles; calibration of the device requires using a sample of the rock dust employed; this is usually limestone but occasionally dolomite or gypsum. A small americium 241 source is used with a scintillation detector whose output feeds a rate meter. The source-detector geometry used was chosen to reduce the effects of variation in bulk density. Accuracy of the system is within plus or minus 3 percent for most mixtures. The instrument is portable and completely self-contained; the rechargeable batteries supply power for 300 to 400 determinations. (Auth)

<336>
Kotrappa, P., D.P. Bhanti, S.K. Dua, and P.P. Joshi, Bhabha Atomic Research Centre, Health Physics Division, Bombay, India. 1974, July

A Single Centripeter for Rapid Analysis of Long-Lived Alpha Emitters in Air. Health Physics, 27, 103-108.

Rapid detection of long-lived alpha emitters such as Pu, U, Th in air is rendered difficult because of the interference of radon and thoron daughter products always present in air. It is known that radon and thoron daughter products are usually associated with the aerosols of particle size less the 0.04 um, whereas the man-made aerosols are usually larger. This property is made use of in a specially designed single stage centripeter sampling at 1000 l/min. This is found to have collection efficiency for long-lived isotopes around 65% and for short-lived isotopes around 3%. As the sample comes out on a filter paper it is possible to obtain an approximate estimate of contribution from radon/thoron daughter products by counting the sample reversed, taking advantage of the alpha energy differences between radon and thoron daughter products and U, Th or Pu. Therefore, even this 3% can be determined and discounted. Comparison is made between the present instrument and the annular impactor, an instrument also based on the principle of size separation. It is concluded that this instrument has several desirable features compared to the annular impactor and is better suited for field use. (Auth)

<337>
Palmer, H.E., W.A. Wagman, and J.A. Cooper, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland WA. 1968

The Determination of the Depth and Amount of Plutonium 239 in Wounds with SI(LI) Detectors. CONF-670521; BNWL-SA-1261; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 164-179), 680 p.

The paper describes the use of a lithium drifted silicon detector for measuring Pu in wounds. The detector is 3 mm thick and has a surface area of 3 cm(E+2). It is housed in an evacuated chamber about one-fourth inch behind a .25 mm Be window and maintained at liquid nitrogen temperature. The resolution of the detector is 0.95 keV for full width at half maximum for a 13.6 KeV x-ray. The superior resolution allows the 3 low energy uranium gamma x-rays of 13.6, 17.2 and 20.2 to be completely resolved. The use of the Si(Li) detector will not increase the sensitivity for the measurement of Pu in wounds even though it has a lower background. The real usefulness of the counter will be in the more accurate measurements of the total activity and an indicator of the depth of the Pu in the wound. (RAF)

<338>
Carver, R.D., and P.J. Dupzyk, Lawrence Livermore Laboratory, Livermore, CA. 1973, June 26

Measurement of the Mass Spectrometer Efficiency in the Isotopic Analysis of Very Small Plutonium Samples. UCPL-74430; CONF-730547; Part of Proceedings of the 21st American Society Symposium on Mass Spectrometry and Allied Topics held in San Francisco, California, May 20-25, 1973, (p. 351-353).

A method was developed to measure quantitaively and isotopically very small amounts of Pu (10(E-13) g or .016 d/m) in environmental samples (soil, plant and animal tissue, water, air filters). The mass spectrometer used has a double filament surface ionization source, tandem magnets with 60 degrees sectors of 34 cm radius; and computer controlled data acquisition, fast magnetic sweep and on-line data reduction. The source is valve isolated from the analyzer portion and with fast pumping, working pressures of 10(E-7) torr can be achieved in 15 minutes. All Pu samples were traced with 350 pg of Pu 242 for isotope dilution normalization; total Pu content and Pu 240/239 isotope ratios were measured. Extensive chemical purifications were found to affect efficiency measurements but did not cause large losses. (RAF)

<339>
Laurer, G.P., and M. Eisenbud, Not given. 1968

In Vivo Measurements of Nuclides Emitting Soft Penetrating Radiation. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (P. 189-207), 680 p.

This study was performed because of a need for a rapid, convenient method of determining whether exposed personnel have accumulated lung burdens of radionuclides such as Pu 239, Sr 90, Pb 210 and uranium. Measurements of these nuclides are handicapped by the fact that they emit only soft radiations which are difficult to quantitate using conventional techniques. The primary objective is the reduction of background in the low energy region of the spectrum. The results of experiments are given utilizing a 1 mm thick CsI(Tl) crystal in conjunction with a NaI(Il) crystal anti-coincidence system for the quantitative in vivo assessment of body burdens of low energy photon emitters such as

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Pu 239, Sr 90, Pb 210 and natural and enriched uranium. Measurements done to obtain optimum crystal thickness, using S2/B as a figure of merit, have shown a thickness of 1 mm tc be a practical comprcmise for all three nuclides. The use of this thin crystal in conjunction with a NaI(Tl) crystal anti-coincidence system using risetime discrimination is effective in reducing background in the low energy region by approximately 70%, and the Compton continuum of Cs 137 by as much as 70%. The use of this system has led to the development of a prototype, portable in vivo counter with an 8" diameter by 1 mm thick CsI(Tl) detection crystal and an 8" diameter by 2" thick NaI(Tl) anti-coincidence crystal. The crystals are mounted in a moveable rig which allows movement in the X, Y and Z planes. The entire rig, including electronic apparatus without a multichannel analyzer, weighs cn the order of 200 lb. Calibration measurements performed with the large crystal have shown minimum significant measurable levels of activity (MSA's) which indicate that body burdens, more particularly lung burdens, may be measured at a fraction of the MPBB without the use of a steel room. (RAF)

<340>
Not given, American Conference of Governmental Industrial Hygienists, Air Sampling Instruments Committee, Cincinnati, OH. 1972

Air Sampling Instruments for Evaluation of Atmospheric Contaminants. Fourth Edition; 558 p.

This fourth edition of Air Sampling Instruments is a revision and extension of the first three editions published in 1960, 1962, and 1966. The text is organized into five major parts. The first part consists of seven introductory papers which discuss basic considerations in sampling air for specific purposes such as sampling for contaminants in work places for airborne microorganisms, sampling in mines, aerosol sampling for particle size analysis and respirable dust sampling. The second part contains discussions of sampler calibration, and instrumental factors. The third part is devoted to system components, the fourth part to sample collectors including filters, inertial gravitational collectors, electrostatic and thermal precipitators, and the fifth part to direct reading instruments. Each section in the third, fourth and fifth parts consists of an introductory paper and a series of descriptions of air sampling instruments or system components in a standard format. Of the twenty-one technical discussions, eleven are newly prepared for this edition, and the other ten have had major revisions. Two papers have been abstracted separately for inclusion in the data base. (FMM)

<341>
Not given, International Atomic Energy Agency, Vienna, Austria. 1971

Advances in Physical and Biological Radiation Detectors. CONF-701112; STI/PUB/269; Proceedings of a Symposium on New Developments in Physical and Biological Radiation Detectors held in Vienna, Austria, November 23-27, 1970, 742 p.

This symposium sponsored by the IAEA was one of a continuing series of meetings to further the exchange of information on all aspects of personnel and area dosimetry. Particular emphasis was given to a study of dose meters themselves, their radiation-sensitive elements (both physical and biological), their instrumentation, calibration and standardization. International intercomparison studies on standardization and calibration of measuring equipment and scurces were recommended. Growing interest in the development of biological dosimeters was noted. The symposium was attended by 170 participants from 29 member states and 5 international organizations; 62 papers are given in full with discussions. (RAF)

<342>
Arnold, J.S., and C.T. Wei, Hines Veterans Administration Hospital, Department of Nuclear Medicine, Hines, IL; Kansas City General Hospital and Medical Center, Department of Pathology, Kansas City, MI. 1972

Quantitative Morpholoy of Vertebral Trabecular Bone. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 333-354), 552 p.

The surface area of trabecular bone, the mean thickness of trabeculae, the marrow space between trabeculae (and mean paths), and % bone were measured in vertebral trabecular bone in 35 "normal" humans. The data serves as both a 3 dimensional quantitative unique example of quantitative morphologic study in aging, as well as a data base for dosage calculations in alpha plus beta bone-seeking radioisotopes. The human vertebral trabecular bone is composed of three types of structure: longitudinal and transverse trabeculae, and longitudinal plates. The numbers of each of the structures per cc of medullary tissue were measured as well as their dimension in 5 acutely dying cases in each decade of adult life, using a thick block microradiographic technique. The surface area per cc of medullary tissue and per gm of ash were calculated from the measured dimensional values. Comparison of the values for % bone calculated from dimensional measurements and those measured by water displacement gave a correlation coefficient of 0.86. Calculated and measured, trabecular spacing gave correlation of 0.73 to 0.90. These results validate the geometric model and the accuracy of measurements. Ruling out 2 cases with focal traumatic changes results in a correlation coefficient of above 0.9 for the above parameters. (Auth)

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<343>
Adams, N., and N.L. Spoor, National Radiological Protection Board, Harwell, England. 1974

Kidney and Bone Retention Functions in the Human Metabolism of Uranium. Physics in Medicine and Biology, 19(4), 460-471.

The retention of uranium by bone and kidney has been re-evaluated taking account of recently published data for a man who had been occupationally exposed to natural uranium aerosols and for adults who have ingested uranium at the normal dietary levels. For lifetime occupational exposure to uranium aerosols the new retention functions yield a greater retention in bone and a smaller retention in kidney than the earlier ones, which were based on acute intakes of uranium by terminal patients. Hence bone replaces kidney as the critical organ. The occupational maximum permissible concentration in air for U 238 and for natural U based on radiological considerations using the ICRP(1959) lung model and the new retention functions are slightly lower than for the earlier ones. For U 238 the maximum permissible concentration determined by chemical toxicity remains the more restrictive. (Auth)

<344>
Andersen, B.V., P.F. Bramson, and H.V. Larson, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1971

Dosimetry of Alpha Emitters in the Lung. CONF-681013; BNWL-SA-1765; Part of Proceedings of a Symposium on the Dosimetry of Low Energy or Short Range Irradiations held in Menton, France, October 9-11, 1968, (p. 58-68).

The lung and lymphoid tissue may well be the critical organs for many industrial exposures to the insoluble actinide radioaerosols. "In vivo" lung measurements provide the primary data for evaluating exposures and subsequent internal dose. A useful secondary method involves fecal sampling and extrapolation by lung modeling and particle size information to obtain a measure of the lung content. A review is briefly presented of experience with "in vivo" lung measurements, fecal excretion, particle size analysis and isotopic composition in their relation to the best dosimetry currently possible for plutonium alpha emitters in the lung. Experience in the operation of several prototype systems for the detection of uranium and plutonium isotopes and Am 241 in the lung is discussed. For natural and enriched uranium, a lung counter with a 9-inch diameter by 4-inch thick sodium iodide crystal provides a detection level equivalent to about 20 percent of a lung burden. Several lung counting systems are available for measuring the x and gamma rays from plutonium and americium. If Am 241 is present, four 12 cm diameter by 1 centimeter thick sodium iodide crystals mounted on low-noise photomultipliers and located on both the front and the back of the chest are utilized. Such a system will detect about 0.1 nCi of Am 241 which can be related to the deposition of plutonium in the lung when the ratio of Pu 239 and Am 241 is known. Reasonable values for this ratio may range from 5 to 20; thus indicating a lung deposition of from 0.5 to 2 nCi of Pu 239. Thin sodium iodide crystal (1 mm thick) arrays and proportional counters are also available for detecting the 17 keV x rays from plutonium isotopes. The detection level of these counters is about 10 nCi. A projection chest phantom was designed and constructed that is especially useful for calibration of "in vivo" lung counters when measuring low energy x-ray and gamma rays (10-100 keV). This inexpensive phantom provides complete variability of chest thickness and incorporates bone structures of a bone equivalent material. (Auth)

<345>
Beach, S.A., G.W. Dolphin, F.P. Duncan, and H.J. Dunster, United Kingdon Atomic Energy Authority, Health and Safety Branch, Radiological Protection Division, Harwell, England. 1966

A Basis for Routine Urine Sampling of Workers Exposed to Plutonium 239. Health Physics, 12, 1671-1682.

A routine program for the measurement of plutonium in urine is discussed in relation to the other methods of controlling the internal radiation dose of those working with plutonium. The urinary excretion pattern following intakes of plutonium compounds is considered and a value for Q, the maximum body content applicable to all compounds, if proposed. A reference level and an action level for urinary excretion rates are suggested. Factors influencing the choice of sampling procedure and frequency are discussed. An example is given showing how the reference level and action level are used in a typical sampling program. Special mention is made of the managerial actions which are taken when a worker's urinary excretion exceeds the reference level and the action level. (Auth)

<346>
Bevan, J.S., and A.K.M.M. Haque, Borough Polytechnic, Department of Physics, London, England. 1968

Some Speculations on the Carcinogenic Effect of Inhaled Alpha-Active Material. Physics in Medicine and Biology, 13(1), 105-112.

Calculations are reported on the possible size of malignant foci in cases of lung cancer attributable to the inhalation of alpha-active material. The calculations are based on the probable dose-incidence for cancers, the radiation sensitivity of lung cells and the actual dose to the lung cells. It is shown that the number of cells in these foci probably lies between 15 and 20, and that the proportion of cells in the bronchi damaged by low doses of radiation may be as high as 20% to 25% of the cell population at risk. (RAF)

<347>
Brueuer, F., and E. Righi, Comitato Nazionale per l'Energia Nucleare, Division of Health and Controls, Rome, Italy, Comitato Nazionale per l'Energia Nucleare, National Laboratories, Medical Service, Rome, Italy. 1974, February

Toxicology of Transportable Uranium: A Critical Contribution to Health Protection of Workers. CONF-730907 (part 1), Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Corgress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 736-742), 1475 p.

The chemical toxicity of uranium is of importance in the evaluation of the risk of internal contamination because of the transportable compounds of the element. The risk becomes most relevant when one has to deal with natural uranium or long-lived

<347> CONT.
uranium isotopes. The maximum permissible concentrations recommended by ICRP and the other limit values proposed are based on the results of experiments that, though complete and valid in their general outline, are affected by the limited technical possibilities available when affected. Since now the possibilities of detecting renal lesions are remarkably improved, it could be useful to review the problem of the chemical toxicity of uranium both on the basis of the advanced techniques available and on the experience gained in the field of health protection in nuclear environments. In fact modern techniques allow a relatively easy detection of even slight modifications and of their characteristics, at the same time the analysis of very small biological samples is possible. It is mentioned that studies carried out on other renal toxic substances, like cadmium, are giving very interesting results. (Auth)

<348>
Casarett, L.J., University of Rochester, School of Medicine and Dentistry, Department of Radiation Biology, Rochester, NY. 1960

Some Physical and Physiological Factors Controlling the Fate of Inhaled Substances. 2.. Health Physics, 2, 379-386.

Some of the mechanisms by which particles are cleared from the lungs are discussed such as ciliary activity of the epithelium, phagocytosis, lymphatic absorption and solubilization. Emphasis has been placed on relatively insoluble particles deposited in alveoli. Mentioned are the high concentrations of uranium oxide in lymphatic organs. Work on plutonium oxide indicates that the compound deposited in the lungs is eventually cleared via ciliary action, but it also appears that lymph node accumulation of plutonium oxide is considerable. Those aspects of lung clearance mechanisms are discussed which are pertinent to the calculations of the radiation dosage to the lung as usually performed. (RAP)

<349>
Daburon, M.L., and I. Jeanmaire, Commissariat a l'Energie Atomique, Centre d'Etudes Nucleaires, Fontenay-aux-Roses, France. 1974, July

Calibration of a Large Area Proportional Counter for Plutonium 239 X-ray Detection in Lungs. CEA-R-4580, 27 p.

A method of calibration of a proportional counter for plutonium measurement in the lung has been developed on the basis of the difference of absorptions of the 60 keV ray of Am 241 external source by an individual and a phantom. The difference is converted into soft tissue (muscle) equivalent thickness, allowing to correct the phantom calibration factor for each subject. As an anthropomorphous phantom is used, an equivalent absorption of chest bones and lung is assumed for the subject and the phantom. The calibration factor, for an average sized individual is 58 counts per minute for 1 uCi of Pu 239 in the lung. (Auth)

<350>
Duncan, K.E., United Kingdom Atomic Energy Authority, Health and Safety Branch, Radiological Protection Division, Oxford, England. 1964, January

Some Aspects of the Prevention and Treatment of Excessive Internal Radioactive Contamination. British Journal of Radiology, 37(434), 120-123.

Some of the methods of reducing the radiation dose to critical organs following accidental intake of radioactive materials are reviewed. More detailed consideration is given to the place of isotope dilution methods with special reference to intakes of radioiodine and to the reduction of internal contamination by the administration of chelating agents with special reference to intakes of plutonium. When the use of chelating agents is considered there are two underlying problems. One is the need for the assessment in real terms of the hazard of certain quantities of radioactive materials in particular organs of the body and the second is the lack of capacity to estimate early and accurately the actual amounts of some radioactive substances in patients. (RAP)

<351>
Evans, R.D., A.T. Keane, and M.M. Shanahan, Massachusetts Institute of Technology, Department of Physics, Cambridge, MA. 1972

Radiogenic Effects in Man of Long-Term Skeletal Alpha-Irradiation. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 431-468), 552 p.

In the absence of human-injury data, some radiation protection guides for Pu 239, Sr 90, and other bone-seeking radionuclides are founded on the human radium base-line or reference standard of 0.1 uCi Ra residual burden, combined with radionuclide toxicity ratios determined from observations on long-lived experimental animals. In the M.I.T. series of human long-term radium cases, from a presently identified population of about 2200 individuals, some 600 have so far been studied (1970) while living plus about 60 after death through autopsy specimens, exhumations, or willed bodies, in addition to 120 matched control individuals. At average skeletal cumulative dosages above about 1000 rads marked radiobiological effects were seen. Among the epidemiologically suitable (unselected) high-dose cases the cumulative incidence of bone sarcomas plus head carcinomas is about 0.28. The tumor appearance time in humans seemed to increase with decreasing dosage, as it does in beagles, such that there would be a domain of dosages for which the required tumor appearance time exceeds the life span, thus defining a practical threshold dosage. In more than 500 individuals below about 1000 rads no radiogenic tumors or significant skeletal effects were seen and there was no discernible life-span shortening. No smooth analytical function had been found which gives a close fit to our response vs. dosage-data for unselected cases over the entire range of dosage. In view of the current widespread publicity given to extravagant death-predictions from low doses of radiation, the origin and proper use of the UNSCEAR-ICRP linear nonthreshold models in formulating maximum-risk estimates for large-population exposures was reviewed. In the dosage domain below about 1000 rads, the probability that the observation of zero radiogenic tumors in over 500 individuals was merely a statistical fluctuation from the UNSCEAR-ICRP linear nonthreshold model was 1 in 5 million, thus strongly rejecting this model. The rejection became even greater when the UNSCEAR-ICRP model was applied to the ANL-ARCH radium cases and the Thorotrast

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cases. In humans undergoing long-term skeletal x-irradiation there was evidence for recovery processes and dose-rate dependence. Life-long observations were required before the response-vs.-dosage relationships were certainly the final values. For a significant fraction of the radium and mesothorium subjects the life span will extend beyond the year 2000. Vigorous and long-term efforts will be exerted by the AEC's Center for Human Radiobiology to obtain the maximum information from this unique, inadvertently exposed, and irreplaceable human population. (Auth)

<352>
Frost, H.M., Henry Ford Hospital, Department of Orthopedic Surgery, Detroit, MI. 1972

An Efficient Way to Analyze Bone Affections. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 293-304), 552 p.

Using established organizational and statistical properties of biological systems, one can devise a strategy of skeletal research which respectably minimizes the probability that one will choose an inappropriate or irrelevant subject to study, and effectively enhances the probability that the subject of study and method of procedure will prove relevant to physiological and pataclogical prchlems related to human disease. This article sketches in very brief fashion some of the reasoning underlying such strategy, and one direction which one might take in attempting to implement it. (Auth)

<353>
Gus'kova, A.F., and G.D. Baysogolov, Not given. 1971

Pathogenetic Classification and Basic Etiological Factors of Radiation Sickness in Man. AEC-tr-7401; Part of Gus'kova, K. and Baysogolov, G.D., Radiation Sickness in Man, (p. 25-38), 560 p.(Russian)

A classification of radiation sickness in man is proposed based primarily on the relationship of biological effects to the dose of irradiation as systematized by B. Bayevskiy in 1956. The two basic variations of radiation sickness are due to either total comparatively uniform irradiation or to localized irradiation in a definite segment of the body or organ. The entire evolution of the response of the organisms and its outcome is divided into acute (subacute) and chronic forms of radiation sickness. The several forms of acute radiation sickness with respect to the leading pathogenesis are distinguished as acute radiation sickness with a) primary lesion of the nervous system (cerebral form), b) with secondary lesion of the nervous system (toxemic form), c) with predominant lesion of the gastrointestinal tract (intestinal form), and d) with predominant lesion of the hematogenic organs (typical form). Acute radiation sickness due to whole body irradiation is subdivided into approximate dose ranges of 100-250, 250-400 and 400-1000 R. The outcomes and consequences may be complete recovery, recovery with defects, stabilization of preexisting changes and deterioration with progressive clinical symptoms. In the development of chronic radiation sickness forms due to either whole body or partial irradiation, 3 periods are schematically distinguished: the period of formation of the disease, the recovery period and the period of outcomes and results of radiation sickness. The degree of expression of clinical manifestations may reach light, moderate, severe and extremely severe degrees. The disease, just as in acute radiation sickness, may end in complete recovery, recovery with defects, stabilization or deterioration of health with a number of syndromes of polyethiological origin. The criteria of the degree of severity of chronic radiation sickness due to uniform whole body irradiation include the extent of the pathological process (the involvement of organs and systems with different degrees of radiosensivity in the response to irradiation), the nature and degree of deviations (functional, anatomical, or structural changes), the degree of reversibility of pathological phenomena, the completeness of recovery after the cessation of irradiation and the implementation of therapeutic measures. (RAF)

<354>
Igitman, A.T., R. Manoli, G.H. Schmiclt, and R.A. Holmes, Medical College of Wisconsin, Division of Nuclear Medicine, Department of Radiology, Milwaukee, WI. 1974, April

An Assessment of Alveolar Deposition and Pulmonary Clearance of Radiopharmaceuticals After Nebulization. American Journal of Roentgenology, Radium Therapy and Nuclear Medicine, 120(4), 776-781.

A group of clear, nonviscid radiopharmaceuticals (Tc 99m04, Tc 99m-Sn-phytate, In 111 Cl3, In 111 DTPA) were evaluated using an ultrasonic nebulizer and scintillation camera to determine the consistency of deposition in the alveoli at normal tidal breathing, systemic absorption and regional or total lung ventilation. The ultrasonic nebulizer used produced particles of 1.0 u or smaller. Twelve healthy volunteers without evidence of lung disease inhaled 10-20 mCi of the Tc 99m compounds or 2 to 5 mCi of the In 111 compounds. Of the four agents nebulized, the Tc 99m-Sn-phytate demonstrated the best alveolar deposition and the slowest pulmonary clearance. Only a minimal amount of the radiopharmaceutical was deposited in the tracheobronchial tree and negligible systemic absorption occurred. The slow clearance allows imaging from 4 views routinely with excellent resolution and a relatively low radiation dose to the lungs. (RAF)

<355>
Jackson, S., and G.W. Dolphin, United Kingdom Atomic Energy Authority, Health and Safety Branch, Radiological Protection Division, Harwell, England. 1966

The Estimation of Internal Radiation Dose from Metabolic and Urinary Excretion Data for a Number of Important Radionuclides. Health Physics, 12, 481-500; AHSB(RP)-R-51; 21 p.

Investigation of an individual case of accidental intake of a radionuclide by determination of the amount of radionuclide in urine has as its object the best practicable estimate of the radiation dose commitment to the critical organ. For this purpose, it is desirable to analyze a carefully planned series of urine samples, in order to diminish the uncertainty attaching to single, isolated results and to provide data for a searching comparison with the best documented cases of defined intake, which

<355> CONT.
provide the basis for interpretation. The primary purpose of routine urine analysis of samples from a group of radiation workers is to detect any significant intake which has otherwise escaped attention. It is convenient to deduce from the available metabolic data an investigation level of urinary excretion rate below which no action is judged to be necessary, but above which investigation of the cause of intake and consideration of further action is required. A review is presented of the human data available on the metabolism and excretion of cesium, phosphorus, polonium, plutonium, radium, strontium, tritium and uranium, and values of investigation level are suggested for these radionuclides. (Auth)

Figure 3 shows urinary excretion of Pu after an intake of 0.04 PuCi

<356>
Lagerquist, C.R., S.F. Hammond, D.L. Bokowski, and D.B. Hylton, Dow Chemical Company, Rocky Flats Division, Golden, CO. 1971, September 17

Summary of the Distribution of Plutonium in the Tissues of Occupationally Exposed Workers. RFP-1783; 13 p.

This progress report deals with an ongoing tissue sampling program to check on methods of estimating systemic burdens of Pu from urine analysis. Of the 12 cases of tissue donation, 2 had less than detectable amounts in their tissues. Total amounts of Pu in the body extrapolated from tissue analysis were compared to the amounts estimated to be present from previous urine samplings. Calculated systemic burdens from urine analysis were consistently on the high side. Results seem to indicate that Pu concentrations were highest in the lungs and lymph nodes, followed by liver and bone. (RAE)

<357>
Langham, W.H., Los Alamos Scientific Laboratory, Los Alamos, NM. 1957

Excretion Methods. The Application of Excretion Analyses to the Determination of Body Burden of Radioactive Isotopes. British Journal of Radiology, Supplement No. 7, 95-113.

The rate of urinary and fecal excretion of Pu changes with time. A graph is given showing the percentage of the original dose of Pu excreted per day by human subjects as a function of days after exposure over a period of five years. The data show that about 0.8% of the intravenously injected dose was excreted on the first day, and that only during finite periods of time could the excretion curves be represented by simple exponentials. Even after five years the rate of elimination of Pu from the body still seemed to be changing. Some data are presented showing the total amount of Pu excreted during periods of time ranging from 10 days to 50 yr. From the values, it appears that the concept of a biological half-time cannot be applied in the case of Pu, and solution of the integrated expression for the 50% excretion time suggest that about 200 yr. may be required for man to eliminate one-half of his body burden. Specific expressions for the coefficients of elimination of Pu, based on excretion data for the first 138 days are given. Other expressions developed are used to demonstrate general methods for the determination of body burden from urine analyses following single acute, variable chronic and chronic invariant exposure, when the urinary excretion fails to follow a simple exponential pattern. The problems of applying urinary to fecal ratios as a measure of lung burden are discussed and certain generalizations are suggested. One suggestion is that insoluble particles PuO2 are removed with half-times of a few weeks and about six months presumably by two different mechanisms. Both methanisms apparently involve transport through the GI tract. About 5 to 10% of the inhaled dose may enter the blood stream rapidly and constitute the systemic burden. While urinary excretion data are a measure of systemic burden, fecal excretion may be quantitatively related to pulmonary elimination of relatively insoluble materials and to the burden of such materials deposited in the lung. Equations are given for estimating systemic and lung burdens from the assay of urine and fecal samples. A general model for the retention, distribution and excretion of inhaled radioactive aerosols is presented. The application of whole body counting for determining internal body burdens of radionuclides, and the limination of the method are discussed. (FWM)

Table 1 shows integrated values for urinary-fecal excretion of Pu in % administered dose at various times. Table 3 shows fecal to urinary excretion of Pu by Los Alamos waters in relation to model of exposure.

<358>
Lushbaugh, C.C., P.J. Cloutier, G. Humason, J. Langham, and S. Guzak, Oak Ridge Institute of Nuclear Studies, Medical Division, Oak Ridge, TN; Los Alamos Scientific Laboratory, Health Division, Los Alamos, NM; Dow Chemical Company, Rocky Flats Division, Medical Department, Golden, CO.. 1967, October 18

Annals of the New York Academy of Sciences, 145, 791-797.

Autoradiographic and histologic study of eight dermal lesions in man, caused by accidentally implanted particles of metallic plutonium, revealed that a minute granuloma resulted in which after four or more years collagenous degeneration and liquefaction occurred. A comparison of the lesions with granulomatous and fibrotic lesions induced by thorotrast suggested that softening of the granuloma in the thorium cases was more likely due to the chronic effect of the radiation exposure of the blood vessels than upon the collagen fibers themselves. The breakdown of collagen fibers around plutonium deposits, however, seems to be related to the relatively enormous dose rate to which these fibers were exposed. (Auth)

<359>
Magi, A., and K. Santa, Statens Stralskyddsinstitut, Department of Radiation Physics, Sodersjukhuset, Stockholm, Sweden; Institute of Radiation Physics, Stockholm, Sweden. 1973, June

Finger Exposure from the Handling of Short-Lived Radionuclides. SSI-1973-14; 11 p.

Measurements were made with TL dosimeters to test the amount of finger exposure received by two nurses working with Tc 99m (1 mCi) and In 113m (1.5 mCi) injections for liver and lung scintigrams respectively. A detailed description of injection handling techniques is given. Doses received by each nurse were calculated for each radionuclide separately

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because of different energies, half-lives and handling techniques . For Tc 99m the dose to the fingertips was 9 and 16 mrads/injection, for In 113m 13 and 31 mrads/injection for the right and left hand respectively. The calculated doses per year received by the nurses was much lower than the MPD of 75 rem. (RAF)

<360>
Marks, E.K., G. Sacher, and L.O. Jacobson, University of Chicago, Metallurgical Laboratory, Chicago, IL. 1949, February

Hematological Studies of Plutonium Project Personnel, Effect of Exercise of Leukopenia, A Statistical Analysis. AECD-2133; 20 p. (Declassified July 22, 1948)

Leukocyte and differential leukocyte counts were made on 35 subjects immediately before, immediately after, and 15 minutes after the subjects performed a standing running exercise. These individuals were male and female employees of the Metallurgical Laboratory. One group selected was potentially exposed to ionizing radiation, the other group had no known exposure to significant amounts of such radiations. Certain individuals in the potentially exposed group had leukopenias; radiation exposure was suspected in the etiology of these leukopenias. Upon analysis no difference in response to exercise of these 2 groups was noted; all responded with an increase in leukocyte values immediately after completion of the exercise. No change in the stage of maturation of the polymorphonuclear neutrophils or morphological change in the lymphocytes was noted in either group. (Auth) (RAF)

<361>
Matsuoka, C., K. Yoshikawa, and T. Fukumoto, National Institute of Radiological Sciences, Chiba, Japan. 1968, September; 1967, September

An Application of Ultra High Speed Alpha Autoradiography in the Detection of Plutonium 239 Skin Surface Contamination. NSJ-tr-136; 11 p.; Journal of Japan Health Physics Society, 2(3), 121-127; Hoken Butsuri, 2, 121-127.

A high speed alpha-radioautographic technique was applied for the detection of Pu 239 skin surface contamination to obtain accurate information on the contaminated area around the wound. Silver activated zinc sulfide was used as an intensifier in combination with a high speed Polaroid film. The intensifier film mounted on the double aluminum coated Lumiler film was interposed between the skin and the photographic film. All of the above autoradiographic procedure was applicable without dark room use by employing a special light-tight attachment. The shape of the contaminated area with about 100 dpm Pu 239 contamination of skin can be identified by an exposure of several minutes by this method. (Auth)

<362>
McInroy, J.F., M.W. Stewart, and W.D. Moss, Los Alamos Scientific Laboratory, Health Division, Industrial Hygiene Group Los Alamos, NM. 1974

Studies of Plutonium in Human Tracheobronchial Lymph Nodes. LA-UR-74-1454; CONF-740930; Part of Proceedings of the 14th Hanford Biology Symposium on Radiation and the Lymphatic System held in Richland, Washington, September 30-October 2, 1974, (18 p.).

Since 1959, tissues from 70 former employees of the Los Alamos Scientific Laboratory with occupational exposures to plutonium have been examined following autopsy. Chemical analyses of selected tissues were performed to determine the amount of plutonium in the body at the time of death. Based upon the measured tissue concentrations of plutonium, extrapolations of total body burdens were made. Exposure in most cases was to inhaled plutonium oxide aerosols. Thirty-three of the measured cases had plutonium depositions in the tracheobronchial lymph nodes ranging from 0.1 to 4000 dis/min per gram of tissue (0.05 to 1800 pCi/g). The duration of exposures ranged from 4 to 30 years. Microscopic examination of representative sections of these lymph nodes revealed no abnormalities other than those which were directly attributable to the basic disease which caused the demise of the various persons in this study. The size distribution of plutonium particles in nodes from one case was determined by exposure of tissue sections to nuclear track film. The estimated mass median diameter of the particles was 0.3 um and the distribution had a geometric standard deviation of 1.6. It is estimated that 95% of the individual particles um had corresponding plutonium concentrations between 0.001 and 0.22 pCi. (Auth)

Table 1 shows concentration of Pu and Am in the tracheobronchial lymph nodes of a Pu worker.

<363>
Merritt, M.L., M. Cowan, J.W. Reed, and J.D. Shreve, Sandia Corporation, Albuquerque, NM. 1959, July

Airborne Plutonium from Weapons Accidents. SC-4326(TR); 33 p. (Secret>)

<364>
Nelson, I.C., L.J. Kirby, and W.W. Thomas, Jr., Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1974, August

Evaluation of Postmortem Tissue Samples. BNWL-1850 (Part 1); Part of Thompson, R.C., et al, Annual Report for 1973, (p. 100-101), 162 p.

A collection of postmortem tissue samples (lung, liver, bone and tracheobronchial lymph nodes) from individuals residing or formerly residing in the vicinity of the Hanford complex is made in order to establish baseline quantities of significant radionuclides as distributed within the body and as related to age, occupation, geographical residence and point in time, in conjunction with establishing the environmental impact of nuclear facilities. Postmortem studies are required because present methods of in vivo measurement do not give adequate data on such important radionuclides as Pu 239. Analyses of postmortem tissue samples and blood samples are also performed for the U.S. Transuranium Registry. A four- detector alpha-spectrometer system was installed, which will permit isotopic analysis of alpha-emitting plutonium isotopes in tissue samples. In addition, this apparatus allows use of plutonium tracers such as Pu 236 and Pu 242 with which chemical yield of the analytical process can be checked in the processing of each sample. (FMM)

<365>
Norwood, W.D., Hanford Atomic Products Operation, Health Operations, Richland, WA. 1960, January

DTPA-Effectiveness in Removing Internally Deposited Plutonium from Humans

DTPA has been shown to be about as effective in treating a small series of humans as previous work by others has shown it to be in removing deposited plutonium from rats. Six humans were treated with doses varying from 0.1 to 2.0 gm of DTPA daily. Rate of elimination of Pu 239 via the urine was increased by factors ranging from 45 to 120, which is much better than any agent previously used. One employee developed a mild kidney irritation, possibly as a result of treatment. This cleared over night and did not recur upon resumption of treatment. Treatment should be started as quickly as possible following an accident in which it is estimated that the maximum permissible deposition of Pu 239 has been exceeded. Where the deposition exceeds the maximum permissible by a large factor, the daily dosage may be doubled or tripled initially. When used for more than a few days, a dose of 1.0 gm two or three times per week for three weeks is recommended to be alternated with periods of three weeks of no treatment. This drug should not be used in the presence of nephritis or other kidney pathology and should be used only with proper evaluation of the patient's renal status before, during, and after therapy. (Auth)

Table 1 shows effect of DTPA on urinary excretion of Pu in man.

<366>
Norwood, W.D., Hanford Atomic Products Operation, Richland, WA. 1962, July

Early Diagnosis and Treatment of Individuals Who Have Excessive Depositions of Radioisotopes. Journal of Occupational Medicine, 4(7), 373-382.

Radioisotopes may enter the body by ingestion, inhalation or absorption through the intact or injured body surface. Inhalation is the most usual method of entry in occupational contamination. Many factors influence the deposition, clearance, translocation, and excretion of inhaled particles. The influence of solubility and particle size are of special importance. A lung model may be helpful in making an educated guess to determine necessity for treatment when specific data are not available. Measurements of radiation emanating from the body and of the radioactive material in urine, feces, blood, exhaled air, and biopsy material may be of great help in estimating the amount and identity of deposited radioisotopes. Tables of maximum permissible body burdens of the most dangerous radioisotopes are available, as well as other tables giving physical properties and grouping radionuclides according to the relative hazards encountered in handling the materials. General and specific methods are outlined for treating individuals who have deposits of radioactive material on skin, in wounds, in the lungs, and in the body. DTPA is the most valuable agent presently available for increasing the rate of the urinary elimination of plutonium and some of the other transuranic elements as well as uranium and many of the fission products. (Auth)

<367>
Plotnikova, L.A., and G.D. Raisogolov, Not given. 1964

The Effect of Sodium Calcium-DTPA (Pentacine) on the Excretion of Plutonium 239 from the Human Organism. Meditsinskaya Radiologiya, 9, 49-52.(Russian, English Summary)

Five persons who worked for extended time periods in an experimental laboratory with different Pu compounds were under observation. All cases examined were administered 1 g of pertacine (10% solution) for seven days. The authors noted that pertacine exerted a favorable effect on the excretion of Pu 239 from the human organism. (NAF)

This article is translated as report, JPRS-23566.

<368>
Pocquet, G., Y. Quentric, and J.P. Guegaen, Centre de Recherches du Service de Sante des Armees, Clamart, France. 1972

Excretion of Cesium 137, Cobalt 60, Cerium 144, Strontium 90 and Plutonium 239 by Man. CRSSA-1972; Part of Annual Progress Report: Scientific Works, 1972, (p. 79-80), 268 p.(French)

Determinations were made of Cs 137, Co 60, Sr 90 and Pu 239 in the urine and stools of individuals voluntarily contaminated by inhaling radioactive dusts, these dusts being known composition. The daily level of excretion was established for each of the radioisotopes concerned. (FR)

<369>
Poe, D.A., Cornell University, Center for Environmental Quality Management, Energy Project, Ithaca, NY. 1972, March

Health Hazards of the Coal and Uranium Miner. Paper No. 72-7; Cornell Energ Project on ational Energy Needs and Environmental Quality.

Men employed in coal mining operations are exposed to the hazards of long-term coal dust inhalation, which has been positively correlated with a high incidence of pneumoconiosis and its sequelae. Additionally, they are exposed to the risk of mining accidents. Current morbidity and mortality figures reflect past neglect of dust control and safety precautions in the mines. Such neglect has resulted in escalating health costs for medical care, disability pensions, and Black Lung Benefits. Present occupational health costs amount to 58 million dollars per year. Projection of future health costs is difficult and will depend on the efficiency of preventive measures aimed at limiting exposure of workers to coal dust and mine safety. Uranium workers also have a serious occupational hazard through the inhalation of radionuclides which act as carcinogens in the development of lung cancer. A statistically significant excess of respiratory cancer deaths has been found in uranium miners with long intervals between time of initial exposure and development of malignant disease. Miners are also exposed to diesel exhaust fumes, products from the detonation of explosives, and dusts composed of silica and various metal ores. Dermatitis from abrasive hand cleansers, oils, and other primary irritants are common in uranium miners. The major health hazards of uranium miners are comparable to those of men

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<369> CONT.
involved in fossil fuel mining and processing, viz. pneumoconiosis, lung cancer, and accidents. However on a dollar cost basis it is projected that fossil fuel production is currently a health problem of greater magnitude because of the much larger number of workers in these industries versus those involved in nuclear fuel production. (Auth)

<370>
Ross, D. M., Not given. 1968

A Statistical Summary of U.S. Atomic Energy Commission Contractors' Internal Exposure Experience. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 427-434), 680 p.

In response to an internal exposure information request by AEC, fifty contractors totalled 532 cases. The following information was sought: 1) radionuclide involved, 2) physical and chemical characteristics of radionuclide, 3) route of entry, 4) date of exposure, 5) method of measurement and calculation, 6) kind of operation, 7) extent of deposition in terms of % body burden, 8) organ or part of body affected, and 9) treatment instituted. The time period 1957 through 1966 was covered with a 25% body burden selected as lowest estimated exposure. Enriched U, Pu, tritium, Po 210, I and Sr 90 were the radionuclides involved in internal exposure cases. The diversity of radionuclides, modes of exposure and methods of estimation were so great that few meaningful conclusions could be drawn. Data for each of the six radionuclides are given individually. Five contractors reported a total of 136 internal Pu depositions that exceeded 25% of a body burden. A majority of these cases--105--occurred in two facilities. There were 29 cases during the 10-yr period that exceeded one body burden. The most frequent route of entry was by inhalation--87 cases. There were 33 cases which involved wounds. Most Pu estimations were done by urinalysis. The details of methods varied somewhat but all used Langham's model for estimating internally deposited Pu. (RAF)

Table 1 lists contractors operating major AEC-owned facilities.

<371>
Furdo, J., and J. Sedlet, Argonne National Laboratory, Argonne, IL. 1974, February

Retention and Elimination of Berkelium 249, Californium 249 Following Acute Accidental Inhalation. CONF-730907 (Part 1); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September, 9-14, 1973, (p. 731-735), 1475 p.

A case of accidental inhalation of a small quantity of an ignited mixture of Bk 249 and its decay product, Cf 249, was studied by body radioactivity measurements and excretion analyses during the first year after intake. The initial chest content of about 3 nCi of Cf 249 declined according to a 2-component exponential function of time (half-lives of 25 days and 1210 days). Except for an initial rapid clearance via the feces, the urinary and fecal excretion rates of both nuclides increased with time until 60-70 days after intake, and then declined. If the early fecal excretion was neglected, the results could be described as the differences between two exponential components with half-times of 15-30 days and 90-130 days. (Auth)

See also Report, ANL-8060 (Part 2), (p. 206-217).

<372>
Russell, E.R., and J.J. Nickson, Argonne National Laboratory, Argonne, IL. 1946, October 2

The Distribution and Excretion of Plutonium in Two Human Subjects. CH-3607; 19 p. (Declassified December 31, 1946)

Distribution and excretion studies were made of Pu 239 (+6) citrate in two human subjects given total intravenous doses of 5 and 94.91 micrograms of plutonium respectively. No clinical effect was noted which could be attributed to the biological action of the element in 155 and 16 days of observation respectively. Such changes as occurred in the hematological picture and in liver functions can be attributed to the terminal state of the subject, to the underlying disease, or both. The following tentative conclusions were drawn. The urinary rate of excretion of plutonium in humans is exceedingly low. The evidence would indicate that the "chronic" (150 th day) excretion rate does not exceed 0.01 percent per day of the amount fixed in the body. The fecal rate of excretion of plutonium fixed in the body is lower than the urinary rate by a factor of approximately three. The evidence indicates that the rate of fecal excretion does not exceed 0.003 percent per day of the amount in the body. The highest concentration of the plutonium fixed in the body is found in the bone marrow. The liver concentration has varied so widely in the two cases here reported that it is impossible to predict on a reasoned basis what the general picture might be. The concentration of plutonium in the neoplastic tissue of these cases was not high. (Auth)

<373>
Saxby, W.N., N.A. Taylor, J. Garland, J. Rundo, and D. Newton, Atomic Weapons Research Establishment, Health Physics Branch, Aldermaston, Berkshire, England. 1964

A Case of Inhalation of Enriched Uranium Dust. CONF-448; STI/PUB/84; Part of Proceedings of a Symposium on the Assessment of Radioactive Body Burdens in Man held in Heidelberg, Germany, May 11-16, 1964, Vol. 2, (p. 535-547), 1043 p.

This paper presents the results obtained in the study of a case of inhalation of insoluble enriched uranium dust. The operational background to the case is explained. The results of urine and fecal sampling, and of body radioactivity measurements are presented and discussed. The authors' tentative conclusions include an assessment that the apparent half-life of insoluble uranium dust in the chest was about 1 yr and a note on the fact that the excretion data do not apparently account for all the material leaving the chest, the fact that the fecal excretion rate was higher than the urinary excretion rate for about 1 1/2 yr after inhalation, and the suggestion that at times between 30 and 60 days a factor of 500 may be used to convert daily urinary uranium

<373> CONT.
excretion levels to the level retained in the lung. (Auth)

<374>
Schieferdecker, H., and E. Polig, Gesellschaft fur Kernforschung, Institute fur Strahlenbiologie, Karlsruhe, German Federal Republic. 1972, May

Evaluation of the Lung Burden Resulting from Inhalation of Plutonium Dioxide with the Help of Separation Analysis. KFK-1638; CONF-720562; Part of Koelzer, W. (Comp.), Proceedings of the 6th Annual Scientific Symposium of the Association for Radiation Protection held in Karlsruhe, Germany, May 17-19, 1972, (p. 253-257), 361 p.(German)

The new ICRP lung model was used for the estimation of the lung burden of an accidental inhalation of insoluble plutonium dioxide. A technician was exposed to approximately 3 mg of PuO2 outside the glove box. Immediate urine and feces analysis showed a fecal excretion of 1 nCi during the first 6 days and an activity of 0.1 pCi/urine sample. The dose commitment was calculated assuming clearance from the lungs into the gastrointestinal tract. Lung activity was assessed to be approximately 1.6 nCi. It was found that the estimation of the lung burden from fecal excretion data was easier than from urine analyses. (PAP)

<375>
Schulte, H.F., and H.C. Whipple, Los Alamos Scientific Laboratory, Los Alamos, NM. 1967; 1968

Chelating Agents in Plutonium Deposition--A Minority View. LA-DC-8453; CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Fornberg, E.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 587-592), 680 p.

Cases in which a chelating agent (EDTA) was used to reduce the internal deposition of Pu 239 following an accident were reviewed. The effectiveness of the treatment was evaluated. The factors against routine use of chelating agents in plutonium exposure are summarized as follows: The drugs are of a significant degree of toxicity. The administration of these agents makes early evaluation of the seriousness of the incident difficult. Most clinical situations are not enough to be of real value. The effects on trace mineral metabolism and long term effects are not well known. The only drug currently recommended for this purpose cannot legally be used on humans in the United States. (FMM)

<376>
Snyder, W.S., Oak Ridge National Laboratory, Health Physics Division, Oak Ridge, TN. 1972

The Distribution of Plutonium in Human Tissue: A Preliminary Analysis of Reported Data. CONF-721096; ANL-8014; Part of Proceedings of the 10th Annual Symposium on Bioassay, Environmental, and Analytical Chemistry held Oakbrook Terrace, Illinois, October 10-11, 1972, (7 p.).

The Transuranium Registry was established to collect into one central repository whatever data might be found on workers exposed to transuranic elements. This includes data on concentrations of these elements in tissue collected in autopsy, data on cause of death and/or morbidity, and bioassay data. The hope is that some day this data may provide valuable information on the metabolism of these elements and on the hazards encountered by employees in working with them. The Transuranium Registry has published a number of tabulations of data accumulated at various times, principally data on concentrations in tissue samples collected at autopsy. The study also collects data of those peripherally exposed through occupation or on those living near the site. These might be considered as "controls" for the study. The data published as of September, 1971, have been analyzed to obtain preliminary indications of the distribution of plutonium within the body. As might be expected, respiratory lymph nodes are high whenever inhalation is indicated as the likely route of exposure. The distribution of plutonium between liver and bone is erratic, the liver being high in the majority of cases, but in many cases the bone concentration is high. Attempts are being made to correlate the bone/liver ratio with time of exposure although it is recognized that other factors influence this ratio greatly. Finally, the survey indicates the likelihood that lungs will be high in concentration only during the early periods following exposure. (Auth)

Table 1 shows concentration of Pu in tissue samples from Hanford workers.

<377>
Speight, R.G., C. O. Peabody, and D. Ramsden, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Radiological and Safety Division, Dorchester, Dorset, England. 1964

An Improved Chest Phantom for Studies of Plutonium and Americium in Human Lungs. CONF-648; SII/PUB/84; Part of Proceedings of a Symposium on the Assessment of Radioactive Body Burdens in Man held in Heidelberg, Germany, May 11-16, 1964, Vol. 1, (p. 119-130), 1043 p.

Work is in progress on the problem of measuring plutonium and americium isotopes, either separately or as mixtures, in the human lung. They may be present as point or distributed sources and are detected directly by their low energy x- and gamma-rays. The high absorption of the x- and gamma-rays in the soft tissue, ribs, sternum, spine, etc., makes it difficult to correlate the response of external detectors with a configuration of internal sources. A semi-empirical method must therefore be used in which sources are placed inside a realistic phantom having similar dimensions and absorption properties to the human chest. The design and construction of such a phantom are described and its method of use illustrated. Experimental results are given for the photon absorption of the constructional materials at energies down to 6.25 KeV. Their degree of equivalence to human tissue is discussed. (Auth)

<378>
Tokizawa, Y., Niigata University School of Medicine, Department of Public Health, Niigata, Japan. 1973, April

Studies on Mechanism of Transfer of Radioactive Nuclides from the Environment to the Human Body in the Niigata District, Northern Japan. Acta Medica et Biologica, 20(3-4), 147-161.

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<378> CONT.
The transfer of radionuclides from the environment to the human body was studied for a specific highly polluted area (Niigata district). The radioactive contamination of human organs in the environment-human system shows in general regional differences nearly in proportion to the amount of pollution and accumulation of fallout (long-life nuclides) and is now almost the same or decreased since around 1964 as the peak. The Niigata district is a highly polluted district with seasonal variations, high radioactivity of precipitation in the winter and low in the summer, and the level of these nuclides in the soil, food and human organs is evidently high. The accumulation of Pu 239 in human organs is summarized for the years 1963 to 1970. The level of Pu 239 is highest in the bones, 2.44 fCi/g, followed by the gonad, 1.88 fCi/g and then the spleen 0.44 fCi/g. The amount of Pu 239 in the lungs increased gradually until 1965, and showed a maximum value of 0.193 fCi/g in 1968. In comparison with the measurement values of the USA the bone level of Pu 239 of the Japanese is about 10 times higher. (Auth) (FWM)

Table 5 shows Pu 239 in human organs (cerebrum, lung, liver, kidney, spleen, gonal, bone and muscle). Table 6 shows Pu 239 in human lung (1960-1970).

<379>
Taylor, D.M., Institute of Cancer Research, Department of Biophysics, Sutton, Surrey, England. 1972

Cellular Deposition and Retention of Plutonium 239 in Relation to the Induction of Neoplasms. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 273-280), 552 p.

Greater understanding of the mechanisms by which Pu 239, and other actinides, are transported round the body and deposited in cells and tissues is important in order to permit the extrapolation to man of toxicity data obtained in experimental animals. Studies of the subcellular distribution of Pu 239 in the liver, testes and adrenals of rats have shown that lysosomes are major sites of Pu 239 localization. The possible significance of association of Pu 239 and Am 241 is discussed in relation to tumor incidence in bone and soft tissues. The need for further comparative studies of the subcellular distribution of 239Pu in human and animal cells is emphasized. (Auth)

<380>
Thomas, R.G., Lovelace Foundation for Medical Education and Research, Fission Product Inhalation Laboratory, Albuquerque, NM. 1972

Tracheobronchial Lymph Node Involvement Following Inhalation of Alpha Emitters. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 231-242), 552 p.

It is estimated that 50 years of chronic inhalation of a relatively insoluble material will result in a concentration in the tracheobronchial lymph nodes (TBLN) approximately 300 times greater than that in the pulmonary region of the respiratory tract. The maximum permissible lung burden (MPLB) of insoluble Pu 239 for occupational exposure based upon such an exposure schedule is 16 nCi. Using a 1000 gram lung, the corresponding concentration in TBLN at 50 years would be 4.8 nCi/gram. Spread homogenously over the entire TBLN tissue, this would result in dose rate of approximately 1.3 rads/day. By analyzing autoradiographs of TBLN following inhalation of Am 241 by beagle dogs, it was determined that only about 10 per cent of a given lymph node was absorbing all of the released alpha particle energy, due to the short path length and residence in "hot spots." Thus, the energy-absorbing fraction of the TBLN in an individual containing a MPLB of Pu 239 might receive 13 rads/day. Conversely, if the "hot spot" problem is ignored and the Pu 239 is assumed spread throughout all lymphoid tissue in the body, the dose rate may be reduced by a factor of 50 to 0.026 rads/day. This is still 6 times the recognized permissible occupational dose rate to soft tissues and could be interpreted to suggest a lowering of the MPLB to about 3 nCi. Due to the many uncertainties involved in such a decision at this time, such as the lack of information on the relative sensitivity of nodal tissue, it is recommended that current standards be maintained until more experimental data are available for evaluation. (Auth)

The volume of tissue being irradiated by Pu 239 particles in the tracheobroncial lymph nodes when the lung has obtained the maximum permissible burden is given.

<381>
Thompson, R.C., J.F. Park, and W.J. Bair, Battelle Memorial Institute, Pacific Northwest Laboratories, Biology Department, Richland, WA. 1972

Some Speculative Extensions to Man of Animal Risk Data on Plutonium. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 221-230), 552 p.

Speculative extensions of the available animal risk data to the problem of plutonium oxide inhalation by man suggest that, regardless of the model employed for prediction, the risk of lung tumors is not greatly different from the risk of liver tumors, and both lung and liver tumors are somewhat more likely than bone tumors. Absolute numerical predictions of the tumor incidence to be expected from a "permissible deposition" of plutonium oxide in the lung vary with the model employed for prediction and little reliance can be placed on these numbers. The more conservative approaches, however, lead to predictions of total tumor incidence of a few percent from an initial lung deposit of 0.04 uCi, which is a higher number than one would wish to see associated with a "permissible deposition." (Auth)

<382>
Wolf, W., Kernforschungszentrum Karlsruhe, Karlsruhe, German Federal Republic. 1973

Treatment After Incorporation of Radionuclides. CONF-730349 (Part 2); Part of Feige, Y. (Ed.), Proceedings of the Regional Symposium on Radiation Protection held in Jerusalem, Israel, March 5-8, 1973, (p. 743-760).

In view of the potentially harmful effects of even small amounts of certain deposited radionuclides, the procedures for removing them from the body are of great importance. Some of the decorporation methods would be useful also in the removal of non-radioactive metals incorporated as a result of industrial or environmental exposure. First aid and

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prompt treatment measures after internal radioactive contamination are discussed from the point of view in their practical applicability. Thus, the effects are reviewed of phosphates, sulfates and alginates on intestinal absorption and excretion of alkaline earth metals as well as the action of ferrihexacyanoferrate on cesium and thallium. Furthermore, the high effectiveness of chelating agents shortly after incorporation of certain radionuclides as well as the problems of a prolonged chelation therapy are elucidated and some future possibilities are indicated. (Auth)

<383>
Dolphin, G.W., K.P. Duncan, H.J. Dunster, and S. Jackson, United Kingdom Atomic Energy Authority, Authority Health and Safety Branch, Radiological Protection Division, Harwell, Berkshire, England. 1966

Maximum Permissible Concentrations in Air for Compounds of Plutonium 239. AHSB(RP)P-69; 13 p.

The derivation of the values for maximum permissible concentration in air (MPC) as given in ICRP Pub. 2 (1959) for soluble and insoluble plutonium is briefly reviewed for the cases of bone, liver and lungs as organs of reference. In the model used in ICRP Pub. 2 (1959) for the calculation of the (MPC) for insoluble radioactive dusts in the lung it is assumed that 12 1/2% of the inhaled radioactivity is transferred to the body fluids. This transfer could lead to a build up of radioactivity in a body organ other than the lung. However recent data both from dog experiments and from human autopsies show that this is not the case and the lung is the critical organ following inhalation of plutonium oxide. Inhaled plutonium nitrate is fairly readily transferred to the liver and bone and consequently the more restrictive (MPC), for soluble plutonium namely 2 x 10(E-12) uCi/cm3 (ICRP Pub. 2, 1959) involved. A list of plutonium compounds is given and divided into those compounds behaving like plutonium nitrate and those behaving like plutonium oxide in the human body. (Auth)

Table 1 shows the distribution of Pu in body organs (lung, lymph nodes, liver and bone) following inhalation of Pu oxide and Pu nitrate by dogs.

<384>
Healy, J.W., C.P. Richmond, and E.C. Anderson, Los Alamos Scientific Laboratory, Los Alamos, NM. 1974, November

A Review of the Natural Resources Defense Council Petition Concerning Limits for Insoluble Alpha Emitters. LA-5810-MS; 20 p.

The interpretations of the potential effects of insoluble alpha-emitting particles in the lung, as described in the document supporting the Natural Resources Defense Council (NRDC) petition of February 14, 1974, are reviewed in light of present evidence. The origin of the NRDC proposal lies in the very non-uniform radiation dose to the tissue surrounding a radioactive particle. Some description of the nature of the non-uniformity and the application of the concept of radiation dose to biological problems is given. The Geeseman studies of follicular cancer produced in rat skin are described and the difficulties of applying the results of one organ to another and the fact of species dependence are emphasized. The Mayan data presented includes the Lushbaugh report on a lesion associated with Pu in a wound, and the Gleason case where the individual handled a crate containing a leaking carton of Pu 239 solution and later developed a synovial sarcoma of the left hand. Tamplin's and Cochran's interpretation of these cases are analyzed on the basis of biological and health physics experience. The lung burdens of individuals exposed to Pu during the fire at Rocky Flats were compared with lung burdens in beagles which developed lung cancer by Tamplin and Cochran and the authors draw attention to the difference in size between human and beagle lungs and hence the effect on radiation dose. It is concluded that the theories upon which the proposal is based are not in accord with the evidence and that the theories do not correctly predict the outcome of experiments actually using insoluble alpha-emitting particles. The authors also maintain that the application of the average organ dose to the establishment of limits is still appropriate, although experimentation to narrow existing uncertainties on the effects of non-uniform dose distribution should continue. (Auth)(PMM)

Table 2 gives particle size measurements for Pu operations. Table 3 gives estimated "hot particle" burdens for Los Alamos workers.

<385>
Janes, A.C., and W.F. Kember, Radiological Protection Service, Department of Health and Social Security, Sutton, Surrey, England; Royal Free Hospital, School of Medicine, Department of Medical Physics, London, England. 1972

Dose Measurements from Skeletal Plutonium Compared in Mammalian Species. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 281-292), 562 p.

Measured concentrations of plutonium 239 on endosteal bone surfaces were compared for a series of mammalian species. For 1 uCi/kg body weight injected, the surface concentration on lumbar trabeculae is 140 pCi/cm2 in the rat, 227 pCi/cm2 in the weanling rabbit, 258 pCi/cm2 in the adult rabbit and 444 pCi/cm2 in the adult beagle. On the basis of a model whereby the bones are simply altered in scale from species to species, the concentration extrapolated to man would be approximately 800 pCi/cm2. An empirical model giving a better fit to the observed concentrations in the smaller mammals gave an extrapolated value of approximately 700 pCi/cm2. A higher concentration is predicted when measured values of the bone surface area volume ratios were used to derive the surface cocentration in man. Even if a reliable estimate of the bone surface concentrations for skeletally-deposited plutonium in man were available, leading to an accurate estimate of dose rate to osteogenic tissue, ignorance of the variation between species of the kinetics of normal and malignant cell populations would still give an uncertain estimate of risk. (Auth)

Table 1 gives Pu 239 concentrations on endosteal bone surfaces, dog, rabbit, and rat. Table 2 compares total skeletal uptake between species.

<386>
Sanders, C.L., and E.H. Groff, Battelle Memorial Institute, Pacific Northwest Laboratories,

<386>

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<386> CONT.
Richland, WA. 1974, November

Bibliography: Effects of Radiation on the Lung with References through 1972. BNWL-1870; 53 p.

This bibliography is intended to provide rapid access to the literature on the biological effects of various radiations delivered to the lung of man and experimental animals. A limited number of the more relevant papers published up to 1947 are included along with a comprehensive survey of the literature from 1947-1972. Papers that describe the biological effects of radiations from occupational exposure, clinical diagnostic or radiotherapy exposure and experimental radiobiological studies with animals are included in the survey. Individual emphasis may be on the molecular, biochemical, cytological, cellular kinetic, physiological or histopathological effects of radiations, although the latter emphasis is the subject of the majority of papers. The most-often described radiations include external x-rays, gamma rays, or neutrons and pulmonary deposited beta or alpha emitting radionuclides. Papers concerned only with dosimetry, metabolism of radionuclides, radiographic diagnosis of pulmonary disease, or clinical efficacy of radiotherapy are not included in the bibliography. (Auth)(RAF)

<387>
Snyder, W.S. (Ed.), International Radiation Protection Association. 1974, February

Third International Congress of the International Radiation Protection Association. CONF-730907 (Parts 1-2); Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973 p.

The conference was presented in two parts, together consisting of 237 papers, of which ? were abstracted separately in the data base. In part one the main topics were, radiation perspective in the USA, radiation and man; non-ionizing radiation; radiation effects on animals (including effects of Cf 252, Sr 90, Cs 137, I 131, Pr 147, Pu 239, Am 241 and Np 237); radioecology, such as the distribution of environmental Pu in the Trinity Site ecosystem after 17 years; reactor experiences, waste management and environmental monitoring; late radiation effects; personnel dosimetry including TLD; dose calculations; metabolism of U and transuranium elements; and radiation accidents. In part two, the main topics were, operational health physics; exposure from radiation sources of natural origin; in vivo measurements; exposure from nuclear power; medical exposure; aerosols and lung models; public information, legal aspects, education and training; and metabolism of radionuclides. In addition the 1973 Sievert lecture entitled "Radiation and man" was presented. (TMM)

<388>
Suzuki, M., National Institute of Radiological Sciences, Chiba, Japan. 1973, May

Uranium. Shin Kinzoku, 18(5), 118-123.(Japanese)

Uranium poisoning was examined histologically including reports on poisoning in the Manhattan Project in the United States. In human and animal experiments, the essential poisoning of uranium has been demonstrated to be chemical poisoning and to cause nephritis with uranium, and other diseases related to it. If fuels containing thorium-uranium 233 series are used in the future, radiation injury will appear in the following occasions: 1) when uranium is accumulated in the organs of humans, especially in the lungs and 2) when the human body gets near the place where a great amount of uranium with daughter radionuclides in a great quantity is present. There are differences in the level of poisoning between uranium with valences of 4 and 6; above all, uranium with valence of 6 in aqueous solutions has the ability to produce anionic complexes. The amount of uranium mouse tissue was examined in order to study the kinetics of uranium compounds in the body. The effect of uranium poisoning on nephrons of the kidney during its metabolism is caused by combination of uranium ions with carbon monoxide Anion of monoxide proteins in the cells, which denatures the proteins and destroys the epithelial cells to necrosis. (JA)

<389>
Vaughan, J., Churchhill Hospital, Oxford, England. 1971, April

Haematological Consequences of Radioisotope Incorporation with Particular Reference to Plutonium, Thorium, Radium, Iron and Gold. STI/DOC/10; Technical Reports Series No. 123; Part of Manual on Radiation Haematology, Chapter 21, (p. 215-242).

The technical report reviews the tissue distribution and chemistry, dosimetry and blood dyscrasias of Pu 239, Th 232 and radium isotopes in humans and animals. Also discussed are the absorption, utilization measurements of blood loss plasma turnover and thermal range of T 1/2 plasma clearance and surface counting of Fe 59. Hematological data of man and animals exposed to Pu are inadequate. However, in view of the distribution in marrow, severe blood dyscrasias are to be expected. More detailed information is available on Th which is widely used as a contrast helium in the form of its oxide. Cases of leukemia and non-leukemic blood dyscrasias are well documented in the literature. Humans and animals exposed to radium isotopes way develop leukemia, severe anemias and osteosarcomas. Colloidal gold used for bone marrow scanning has no known hematological effects. (RAF)

<390>
Vaughan, J.M., Churchill, Hospital, Medical Research Council, Oxford, England. 1956

The Effects of Radiation on Bone. Part of Bourne, G.H. (Ed.), The Biochemistry and Physiology of Bone, Chapter 23. Academic Press, Inc., New York, New York, (p. 729-765), 875 p.

The three main sections of this review deal with the general aspects of radiation dosimetry with special relation to bone, the relationships of anatomy and physiology of bone radiation to pathology and dosimetry, and pathological changes induced in bone by irradiation. Anatomic and physiologic factors discussed include the non-homogeneous character of bone, the rate of metabolic turnover, the localization of bone growth in young and old animals, the distribution of vascular tissue, the presence of an extensive crystal surface, and the relationship of bone and myeloid tissue. The pathological changes are classified as either radiation osteodysplasia or radiation neoplasia caused

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by internal or external radiation. Both clinical and experimental data are supported by an extensive bibliography. The data presented show that sarcoma may develop in bone following both external and internal irradiation. In the case of external radiation, the latent period so far recorded has been on the average shorter than the latent period recorded as developing after internal radiation. Tumors following external radiation have developed in the majority of cases after a dose greater than 3,000 roentgens. The dose of internal radiation necessary for tumor development appears to be variable, the lower limit being extremely small. No explanation is available at present for the delayed latent period in the development both of radiation osteodysplasia and of malignancy following the retention of minute amounts of radioactive elements. In assessing risks of response to radiation the extreme variation of susceptibility of individuals should be taken into account. (RAE)

<391>
McKee, F.W., L.L. Clark, B.M. Cole, and R.A. Libby, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1974, September

Dose-to-the-Population Estimates for Use of Radioisotope Powered Cardiac Pacemakers. BNWL-1858; 64 p.

Estimates of the population dose were developed in terms of an equilibrium first-implant rate of 10,000 1973-equivalent radioisotope powered cardiac pacemaker (RPCP) implants per year adjusted for population increases in future years. It was calculated that there would be from 130,000 to 208,000 RPCP's in use in year 2000 (per 10,000 1973-equivalent implants per year). Whole-body dose rates to a standard man phantom from two different implanted RPCP sources were calculated using the QAD P5A computer program. The two sources were the Medtronic Model 9000 using 0.15 grams Pu 238 and the ARCO Nuclear RPCP using 0.40 grams Pu 238. Dose rates from the source were calculated in four directions and averaged to represent a single average dose rate to a person in the vicinity of a pacemaker user. In terms of frontal dose only, dose rates would be 50 to 100% higher than the average in four directions. The RPCP use projections and dosimetry calculations provided input for the REPRAEVE computer program for the dose-to-the-population calculations. The computer program output provides a breakdown of the dose by age and sex for significant classifications of persons who receive the dose such as spouses, members of the household, and work associates. The results of the calculations of the calculations show that the total population dose ranges from 1400 rem/year to 6,000 rem/year. Because of the larger source size in the ARCO Nuclear RPCP, the population doses calculated were approximately twice as great as those calculated with the Medtronic Model 9000. Spouses received the greatest individual doses but these range only up to 15 or 16 mrem per year, while the other household members received on the order of 1 to 3 mrem per year. Doses to both nonwork associates and work associates are in the range of a few tenths of mrem per year. The dose to the general populace, which accounts for 33 to 43% of the total population dose, averages only two to seven micro rems per person per year. None of the exposures to any group appears to be excessive and it was concluded that the population dose from RPCP's does not represent a significant risk. (Auth) (FNM)

Table 1 shows year 2000 population dose estimates per 10,000 1973--equivalent first implants per year. Table 7 shows external dose rates to a standard man phantom from an implanted ARCO RPCP (mrem/hr).

<392>
Rajewsky, B., A. Kaul, and J. Heyder, Max-Planck-Institute for Biophysics, Frankfurt/Main, German Federal Republic. 1964

On the Development of Devices for the Determination of Total-Body Radioactivity in Man: A Historical and Critical Review. CONF-448; STI/PUB/84; Part of Proceedings of a Symposium on the Assessment of Radioactive Body Burdens in Man held in Heidelberg, Germany, May 11-16, 1964, Vol. 1, (p. 15-52), 1043 p.

The in vivo determination of the total-body content of incorporated radioactive substances is important not only to determine the natural content of radionuclides within the human body to obtain fundamental values for the fixation of "maximal body burden" but also for radiation protection to survey continously the employees of e.g. reactor stations, isotope laboratories and clinical hospitals, so that even the lowest incorporations can be detected as early as possible. The determination of the amount of incorporated radionuclides by external direct measurements of the radioactivity goes back to the early 1930's, when the first cases of radium poisoning were examined by means of ionization chambers. Only a few years later a first "Institution for the Physical Diagnosis of Radium Poisoning" was established at the former Kaiser Wilhelm Institute for Biophysics in Frankfurt (Main). This institution carried out in vivo and post mortem diagnoses. In vivo diagnosis consisted mainly of determination of the excretion of Ra 226 and its daughters in feces, urine and the breath. In addition, distribution of the incorporated Ra 226 within the body was examined by means of ionization chambers. However, one of the problems of radiation protection, namely recognition of even low radioactive incorporations as early as possible, could not be taken into account at that time, since the instrumental limit of detection was of the same order of magnitude as the maximum permissible body burden for Ra 226 (0.1 ug/total body). However, it became possible about 15 years ago to determine radioactive incorporations of about one order of magnitude only below the normal Ra 226 body content by means of high-pressure ionization chambers and, later on, by scintillation counters. Furthermore, mainly during recent years, the application of methods for the external direct examination of incorporated radionuclides was extended to clinical and radiological problems concerning the metabolism of different radionuclides. The experimental possibilities of the direct and indirect determination of radioactive incorporation within the human body are discussed in this historical and critical review which is based on the authors' investigations and those of others. (Auth)

Table 9 shows detection limits of whole-body counters in fractions of the MPBB for several radionuclides including Np 239, U 235, Am 241 and Cf 249.

<393>

MEDICAL ASPECTS

<393>
Scott, L.M., and C.M. West, Union Carbide Corporation, Y-12 Plant, Oak Ridge, TN. 1964

Detection and Evaluation of Uranium Exposures. CONF-448; STI/PUB/84; Part of Proceedings of a Symposium on the Assessment of Radioactive Body Burdens in Man held in Heidelberg, Germany, May 11-16, 1964, Vol. 2, (p. 523-533), 1043 p.

Approximately 1800 personnel of the Union Carbide Corporation-operated United States Atomic Energy Commission Y-12 Plant involved in the routine industrial-scale processing of uranium. Personnel monitoring is accomplished by means of urinalysis and in vivo gamma-spectrum analysis programs. The interpretation of data from the two programs and the relationship thereof are presented. Personnel-monitoring results from the two programs are divided into four classes namely low urinalysis and low in vivo results; high urinalysis and low in vivo results; low urinalysis and high in vivo results; and high urinalysis and high in vivo results. The majority of the persons monitored fall into the first class; however, from the exposure standpoint the last three classes are of prime interest. Examples of cases falling into these classes are presented. Cases exhibiting biological half-life in the lung, ranging from less than 100 d to approximately 800 d, are presented and discussed. The cases illustrate that the elimination of uranium from the lung varies both in mode and rate of elimination depending, in part, on the exposure material. Insoluble uranium is excreted by both urine and feces. Urinalyses are usually adequate to highlight potential exposure cases. However, when dose evaluations are to be made, considerations should be given to the possibilities of fecal excretion and moderate extensions of a biological half-life beyond 120 d. To evaluate a uranium exposure thoroughly, urinalyses, fecal analyses, and in vivo spectrum analyses are desirable. Correlation coefficients for results of the two programs, grouping data by type work, are also presented. Correlations ranged from 0 to +0.32. (Auth)

<394>
Reid, K.R., R.C. Henle, and J.M. Selby, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1966; 1968

Prompt Mitigatory Action After Accidental Exposure to Radionuclides. BNWL-SA-962; CONF-670621; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 593-599), 680 p.

Through 1966 there have been 201 injuries at Hanford that were potentially contaminated with plutonium. Measureable quantities of plutonium have been detected in 123 (62%) of these cases. Surgical excision was performed for 78 (39%) of the cases and 12 (6%) were administered a chelating agent. Eleven cases resulted in deposition evaluated at greater than or equal to of the MPBB, four of which were evaluated at greater than or equal to 50%. Some 1,000 cases of accidental exposure to airborne plutonium have been recorded through 1966. Of these only 93 (9%) of the cases resulted in deposition evaluated as greater than or equal to 50%. Nine inhalation cases have been administered a chelating agent. Fifty plutonium inhalation incidents involving approximately 100 persons occurring at Hanford over a two-year period were examined in detail. The ratio of the number of persons exposed to plutonium in an oxide form to the number of persons exposed to plutonium in a nitrate form was 10 to 1. Several types of data are being collected to assist in evaluating inhalation cases in which the plutonium is in a relatively insoluble form. Particle size studies are made of plutonium collected on air samples filters and on nasal smears. Also fecal samples are obtained. Utilizing the ICRP Lung Model and these data it is often possible to obtain a preliminary estimate of the lung burden and the ultimate body burden within a week or two. If available data suggests that the deposition of Pu via break in the skin may exceed 0.01 uCi Pu 239, a temporary work restriction precluding further work with plutonium or other biolcgically similar radionuclides will be issued until a formal evaluation can be completed. If the deposition is evaluated as exceeding 0.02 uCi Pu 239, a permanent work restriction is recommended. This work restriction would also preclude further exposure to plutonium or biologically similar material and preclude or limit further exposure to external radiation as well. Close liaison between radiation protection and medical personnel will continue for several weeks, months or even years in the extreme cases. (Auth)

<395>
Lloyd, E., and J.H. Marshall, Argonne National Laboratory, Radiological Physics Division, Argonne, IL. 1972

Toxicity of Plutonium 239 Relative to Radium 226 in Man and Dog. Part of Stover, B.J. and Jee, W.S.S. (Eds.), Radiobiology of Plutonium. J.W. Press, Salt Lake City, Utah, (p. 377-408), 552 p.

The relative biological effectiveness of Pu 239 compared to Ra 226 in man cannot be regarded as being equal to that which has been found experimentally in dogs because of the different distribution patterns of the two isotopes and the very important differences in bone structures between man and dog. Some of the factors affecting the relative toxicities are: (1) The surface/volume ratio of bone mineral in trabecular bone of the dog was found to be higher than the corresponding values in man by about a factor of two. (2) The burial rate of surface deposits of Pu 239 in a 1.5 year-old dog is at least an order of magnitude greater than in an adult man. This burial rate in dogs appears to be critically dependent on age and decreases rapidly after the age of 1.5 years, the age at which most of the toxicity studies have been performed. (3) The percentage of the marrow volume irradiated by alpha-emitting bone surface seekers is higher in the dog-about 25% compared with about 10% in man. (4) The higher proportion of bone volume per unit volume of the vertebrae in the dog--about 35% as compared with 25% in man-may make the vertebrae in adult man more vulnerable to bone damage. All of these factors would lead one to expect differences in the hazards from Pu 239 and Ra 226 in man and dog. The first two factors would suggest that the relative toxicity of Pu 239/Ra 226 may be greater in man than in 1.5 year-old dog. (Auth)

<395>
National Environmental Research Center, Las Vegas, NV; Nevada Operations Office, Las Vegas, NV. 1974, December

Offsite Surveillance Around the Nevada Test Site, July-December, 1970. Radiation Data and Reports, 15(12), 802-817.

Tritium released by the July through December 1970 flaring operations at Project Pulison was detected in all types of environmental samples collected on the ground in offsite areas except for milk, water, food, food crops, cow feed, urine, and animal tissue. The highest concentration of krypton-85 in air was less than 0.05 percent of the AEC standard, and the highest tritium concentration in air samples was less than 0.5 percent of the AEC standard. The only NTS event that released radioactivity into the offsite environment during this reporting period was Baneberry, on December 18, 1970. A summary is given of the combined estimates of hypothetical infant thyroid doses which were calculated from measured concentrations of airborne radioiodine, concentrations of radioiodine in milk, and external gamma radiation exposures. It is seen that the combined thyroid doses were below 0.5 rem, the radiation protection standard for thyroid doses to a representative population sample. The highest estimated thyroid dose for Baneberry was for the sheepherders who were working between Eureka and Duckwater, Nevada, and using snow for cooking and drinking. Although no snow being used by the herders was collected, inference from samples collected around the area supports a thyroid dose estimate of 0.5 rem plus or minus a factor of 3, which is within the radiation protection standard of 1.5 rem to the thyroid of an individual within the general population. (Auth)

<397>
Alexander, P.F., Pantex Plant, Amarillo, TX. 1974, May 1

Environmental Monitoring Report for Pantex Plant Covering 1973. MHSMP-74-12; 39 p.

An environmental monitoring program has been established for the Pantex Plant which involves air, water, soil and vegetation samplings and analysis. Although Pantex Plant operations involve the handling of significant quantities of uranium, plutonium, tritium and toxic materials, safeguards have precluded potentially hazardous releases of these materials. Release of materials has been restricted to small amounts of natural uranium depleted in the isotope U 235 during occasional explosives test fire shots and tritium which might be found in the local environment at slightly higher than background levels. Concentrations of these radionuclides were well below the accepted AEC criteria. (Auth)(RAF)

<398>
Ames, L.L., Battelle Memorial Institute, Pacific Northwest Laboratories, Water and Land Resources Department, Richland, WA. 1974, February

Characterization of Actinide Bearing Soils: Top Sixty Centimeters of 216-Z-9 Enclosed Trench. BNWL-1812; 74 p.

Under pre-1965 waste disposal practices at Hanford certain actinide-bearing solutions were discharged to the soil in covered trench facilities, e.g. 216-Z-9. A program to examine the soil-actinide relationship in sediments from a disposal facility was initiated. Soil mounts were made of soil recovered from a core or an uncontaminated well drilled alongside the Z-9 trench. The uncontaminated mounts showed that the less than 30 mesh soil was composed of predominately metamorphic rock fragments of the Belt Series, brought down from northern Washington and Idaho by the ancestral Columbia River. Two 4-inch diameter cores, 2 feet in length, were taken from the floor of Z-9 trench. Overlying one of these cores (4-11), was a sludge layer of silica, alumina and water. The core (4-5) had no sludge layer. At least two types of plutonium were found in cores 4-11 and 4-5 by autoradiographic and microprobe examination. The plutonium particles (up to 10 um in diameter and 60 wt% PuO2) were the most conspicuous form. These occurred near the top of the core 4-11, but extended down nearly to the bottom of core 4-5. The second form of plutonium occurred in lesser concentration (<0.4 wt% PuO2) but was found throughout the lengths of both cores associated with silicate hydrolysis. Loss of alkalies and alkaline earths, along with the absence of several metamorphic minerals found in the uncontaminated mounts, indicated extensive chemical attack of soil rock fragments by acidic influent solutions. The locations of the base of the silicate hydrolysis zone, and associated plutonium deposition, are presently unknown. (Auth)(FMM)

Tables 12 and 18 show analyses of Pu and associated elements.

<399>
Balertin, N., C. Weyers, and R. Boulenger, Centre d'Etude de l'Energie Nucleaire, Brussels, Belgium. 1965, July

Plutonium Urinanalysis. BLG-353; 14 p.

A simple method of urinanalysis, sensitive enough to detect 0.08 dis/min of plutonium in 1500 ml of urine, is described. The method consists of a phosphate precipitation followed by the destruction of organic matters by ashing. An anion exchange is used to separate plutonium from other remaining inorganic ions and the final purified plutonium is deposited or electroplated on stainless steel discs and counted in a ZnS scintillator. Ten to twenty samples can be treated per day by two persons, the result being obtained three days after the beginning of the analysis. The recovery of about 3 di./min of plutonium from a litre of urine is 78 plus or minus 4 percent with 95% confidence. (Auth)

<400>
Phat, I.S., Tarapur Atomic Power Station Colony, Environmental Survey Laboratory, Boisar, Maharashtra, India. 1972, November

Need for Environmental Monitoring for Nuclear Installations. Indian Journal of Occupational Health, 15(1), 8-14.

Increased use of radioisotopes for medicine, agriculture and industry, fast growth of nuclear power production and associated nuclear fuel production and reprocessing, produce large amounts of radioactive wastes. The radioactive gaseous and liquid wastes have to be dispersed safely in the environment: In the environment there are many pathways through which the discharged radionuclides can concentrate and reach man.

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The Health Physics Division (HPD) of Bhabha Atomic Research Centre, which is a constituent unit of the Department of Atomic Energy, conducts safety monitoring of environmental radioactive contamination from nuclear installations in the country. The environmental parameters of interest to nuclear installations include seasonal variation of wind, water movement, ecological factors and demography. HPD organized and set up the Environmental Survey Laboratory (ESL) on behalf of the Tarapur Atomic Power Authority when construction of the power reactors began. The laboratory and field research carried out by the ESL to obtain the basic factors required to control environmental radiation exposure is described. Included are studies of soil-plant relation for fallout nuclides, diet-urine relation for fallout nuclides for the local population, and studies of environmental dispersion and reconcentration processes to derive MPC in seawater and beaches. (FMM)

<401>
Bogen, D.C., C.A. Henkel, C.G.C. White, and G.A. Welford, Health and Safety Laboratory, New York, NY. 1971

Tritium Intake in New York City. CONF-710809; Part of Moghissi, A.A. and Carter, M.W. (Eds.), Proceedings of a Symposium on Tritium held in Las Vegas, Nevada, August 30-September 2, 1971. Messenger Graphics, Publishers, Las Vegas, Nevada, (p. 639-646), 807 p.

In an attempt to establish base line amounts allowable for exposure to tritium by the general population three intake categories, diet, air, and fluids were analyzed for their tritium concentration. The food in the diet study was purchased during winter and spring 1970-1971. Samples were freeze-dried to remove and collect loose water from the bulk sample and ashed. Tap water was distilled to remove impurities and electrolytically enriched prior to counting. Water in the ambient air was condensed in a dry ice-acetone bath. The condensed water was also distilled and electrolytically enriched prior to liquid scintillation counting. Dietary tritium intake values were determined in 19 food categories for both loose water and tritium. Some tritium enrichment was observed in the organic fraction of certain food categories. Calculated values for the total tritium intake in New York City were 2700 pCi/day or 0.99 uCi/a for the three modes of intake (diet 0.62 uCi/a, air 0.037 uCi/a and fluids 0.33 uCi/a). (RAF)

Dietary tritium intake by food categories are listed in Tables 1-4. Tritium concentrations in air samples (April 16, 1970-February 25, 1971) and in tap water are listed in Tables 5 and 6.

<402>
Carfagno, D.G., Mound Laboratory, Miamisburg, OH. 1974, July

Mound Laboratory's Air Surveillance System. WASH-1382 CONF-740406, Part of Proceedings of the 2nd AEC Environmental Protection Symposium held in Albuquerque, New Mexico, April 16-19, 1974, Vol. 2, (p. 569-576), 1151 p.

A comprehensive air surveillance system was developed at Mound Laboratory. The system provides for surveillance of the source by continuous sampling and monitoring of stack emissions. The transport conditions are continuously monitored at an on site meteorological station. Wind speed and direction are measured 160 ft above ground level by tower-mounted instruments. Temperatures are also measured at three elevations to aid in determining atmospheric stability. Finally, concentration at the receptor site is determined by continuous air sampling followed by specific radionuclide analysis. Several types of samples are collected at the continuous air sampling locations. Of particular interest is the continuous high volume particulate sample whose monthly composite is analyzed specifically for Pu 238. The annual averages obtained for 1973 range from 1.9 to 57 aCi/m3. Another component of the air surveillance system is a small computer which will collect data, reduce it, modify the atmospheric diffusion equations, and arrive at an atmospheric diffusion model for Mound Laboratory. An unusual aspect of the system is the implementation of offsite sampling programs through the local public health agency. (FMM)

<403>
Cheever, C.L., C.H. Youngquist, P.R. Hirsch, J.C. Hoh, D.S. Janetka, and H.R. Fish, Argonne National Laboratory, Argonne, IL. 1973, January

Effects of High-Level Gamma Radiation Exposure of HEPA Filters. CONF-720823 (Vol. 1), Part of First, M.W. (Ed.), Proceedings of the 12th AEC Air Cleaning Symposium held in Oak Ridge, Tennessee, August 28-31, 1972, (p. 638-645), 899 p.

Evaluation of the effects of stepwise exposure of five 12 x 12 x 6 inch HEPA filters to Co 60 gamma radiation are reported. Two of the filters had glass-pack seals and cadmium plated steel frames, two had glass-pack seals and chromized steel frames, and one had a pressed wood frame. An additional pressed wood frame filter was tested as a non-irradiated control. The filters were irradiated to nominal exposures of 10(E+7), 10(E+8), 5 x 10(E+8), 10(E+9), and 1.5 x 10(E+9) R. At the start and after each period of irradiation the filters were tested at rated flow to determine the percent penetration of compressed air generated DOP aerosol. The filters were then stressed at 2 to 3 times rated flow and the penetration tests were repeated at rated flow. Two of the steel frame filters were irradiated in irradiated in an argon atmosphere and the other filters were irradiated in air. All tests showed acceptable (less than 0.03%) penetration results. There was no significant change in penetration except as measured in the last step for filter number four. Flat sponge neoprene and PVC gaskets were also irradiated in both argon and air as above. The effects were measured by observation, leak rate measurements, and shore durometer hardness tests. The neoprene gaskets were prefered, although they became hard. The PVC gaskets became tacky and were unaccentable. The HEPA filters continued to perform acceptably after irradiation to more than 10 (E+9) R of Co 60 gamma radiation. (Auth)

<404>
Clemente, G.F., Comitato Nazionale per l'Energia Nucleare, Environmental Radioactivity Laboratory, Rome, Italy. 1973

A Comparison of Calibration Techniques for the Assessment of Plutonium 239 Lung Burdens. CONF-730345 (Part 2); Part of Feige, Y. (Ed.),

<404> CONT.
Proceedings of the Regional Symposium on Radiation Protection held in Jerusalem, Israel, March 5-8, 1973 (p. 805-819).

In the measurement of subjects contaminated with Pu 239 the calibration procedure presents many difficulties because of the very low energy of the x rays considered. The attenuation of the Pu 239 x rays escaping from the chest shows a strong dependence upon body size of the subjects. The Pu 239 counting equipment used consists of a twin crystal composed by a 125 mm x 0.5 mm NaI(Tl) crystal, optically coupled to a 125 mm x 50 mm CsI(Na) crystal. The two crystals are connected to a pulse shape discrimination system. The results obtained by using the two following calibration techniques are compared: a) the measurement of thin sources of Pu 239 localized in different positions inside the lungs of a tissue equivalent phantom and the measurement of three human volunteers of very different body size , who inhaled an aerosol labelled with Pd103 as a simulator of Pu 239. The results obtained show that the calibration factors obtained on subjects of very different body build will vary of about a factor of five. As a consequence, if a phantom calibration is employed, a correction factor has to be found which will take into account the variations in the response of the counter due to the different body size of the subjects. In addition, the variation of the response of the counter has been studied as a function of both the position of the crystal on the subject and the individual body size. (Auth)

<405>
Delafield, H.J., J.A. Dennis, and J.A.B. Gibson, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, England. 1973, November

Nuclear Accident Dosimetry. Part 2. Dose Assessment Procedure. AERE-R-7486; 29 p.

This report is one of three associated reports dealing with nuclear accident dosimetry. Detailed operational instructions on methods of dose assessment for the United Kingdom Atomic Energy Agency personnel criticality dosimeter and the installed Np 237 dosimeter are provided. The areas included in this report are general procedures for making a dose assessment, personnel monitoring, dosimeter measurements, body measurements, derivation of doses from dosimeter measurements and estimation of doses from blood, hair and clothing measurements. Dose estimates arrived at by different methods require interpretation and corrections for particular accident circumstances. (PAE)

The appendix gives measuring equipment and calibration procedures, and radiochemical analysis procedures.

<406>
Dolgurev, F.I., G.N. Kajdanovsky, N.V. Porozov, and V.M. Shamov, Institute of Radiation Hygiene, Leningrad, USSR. 1974, February

Monitoring of Low-Energy X-Ray Radionuclide Content in Human Body. CONF-730907 (Part 2); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 957-962), 1475 p.

A 15 cm-dia 0.1 cm thick NaI detector and an Ar-CH4 proportional counter with a 300 cm2 window were used for in vivo measurements of Pb 210, Pu 239 and Am 241 content in human body. The subject's background was deterimend from the correlation of the counting rates in two channels, e.g. for Pb 210: 30-55 and 100-150 keV, respectively. The detectors were calibrated on an anthropomorphous phantom with the thickness of the tissues absorption layer varying from zero to 4 cm. Calculation methods for nuclide content in critical organs and cases illustrating different types of radionuclide distribution in human body are given. (Auth)

<407>
Duba, A., A.E. Abey, and H.C. Heard, Lawrence Livermore Laboratory, Livermore, CA. 1973, November

High Pressure Mechanical Properties of an Area 12, Nevada Test Site Tuff. UCID-16377; 20 p.

The mechanical properties of tuff from instrument hole UG3, tunnel U12e.06 at the Nevada Test Site have been investigated to 1400 MPa. The shear strength increases from about 5MPa unconfined to 12 MPa at 300 MPa mean pressure. A brittle-ductile transition was indicated at about 280 MPa. In unilateral strain, the sample loads to the vicinity of the failure envelope and then is parallel to that envelope up to the highest stresses, 420 MPa. Hydrostatic pressure of 1400 MPa produces about 9% volume compression and 1.3% permanent compaction in this apparently saturated tuff. (Auth)

<408>
Eakins, J.D., and A.E. Lally, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, England. 1972

Simultaneous Determination of Plutonium Alpha Activity and Plutonium 241 in Biological Materials by Gel Scintillation Counting. CONF-710991 (Part 2); AERE-R-6640; Part of Crook, M.A. (Ed.), Proceedings of a Symposium on Liquid Scintillation Counting held in Brighton, United Kingdom, September 13-16, 1971. Heydens and Son, Ltd., London, England, (p. 155-165).

The method described utilizes a simple gel scintillation counting technique simultaneously to determine both Pu alpha activity and Pu 241 in a two-channel Packard Tricarb Model 3214 liquid scintillation spectrometer. By using the procedure given, alpha-emitting Pu at the 1 pCi level and Pu 241 at the 10 pCi level of activity can be adequately detected. (LK)

<409>
Fowler, E.B., R.O. Gilbert, and E.H. Essington, Los Alamos Scientific Laboratory, Health Division, Los Alamos, NM, Battelle Memorial Institute, Pacific Northwest Laboratories, Systems Department, Richland, WA. 1974

Sampling of Soils for Radioactivity: Philosophy, Experience, and Results. LA-UR-74-1339; CONF-740921; Part of Proceedings of the Atmospheric-Surface Exchange of Particulate and Gaseous Pollutants Symposium held in Richland, Washington, September 4-6, 1974, (15 p.).

In many cases, the methods of sampling a soil matrix have not received the attention required when data derived therefrom are to be applied to problems associated with analyses for radionuclides. The import of the soil surface as one ultimate receptor,

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and hence source, of particulate debris in the atmosphere-surface exchange system is discussed. A review is given of aspects of one approach to sampling of soils which has proved successful in a study of extensive areas where contamination with plutonium exists at a wide range of levels. The practical application of the work is reported as well as data identifying one source term. The development and field application of sampling techniques based on a designed random sampling scheme and on knowledge of contaminant distribution are discussed. Typical results from participating laboratories are presented which indicate the degree of success experienced when the approach described is used to obtain data relative to inventory, horizontal and vertical distribution, and species of radionuclide. Problems associated with the requirement to obtain a "most probably representative sample" as well as the need for a common expression of extent of contaminant, are emphasized. The particle problem as its relates to sampling, analyses, and interpretation of data is discussed. (Auth)

Figure 14 shows variation of Pu concentration with depth at Area 13, Nevada Test Site. Figure 11 shows laboratory certificate of Pu 239-240 in large meat samples. Figure 8 shows an autoradiograph demonstrating variation of particle sizes (Palomares soil).

<410>
Freiberg, K.J., and C.G. Haynes, Dow Chemical Company, Rocky Flats Division, Golden, CO. 1974

Emission Monitoring Systems for Plutonium Facilities. RFP-2218; CONF-740807; Part of Proceedings of the 13th AEC Air Cleaning Symposium held in San Francisco, California, August 12-15, 1974, (10 p.).

The primary purposes of monitoring gaseous effluents are to insure that environmental discharges conform to specified guidelines and to evaluate the performance of the air cleaning system. The paper describes a system at a plutonium facility, whose important characteristics are: 1. continuous monitoring with central readout of the amounts of radioactive and chemical pollutants, 2. extensive fixed sample collection, and 3. measurement of the total effluent volume. Also described is a technique for in-service contamination surveys of filter plenums. The system meets the requirements set forth in the "Minimum Design Requirements for New Plutonium Facilities." (Auth)

<411>
Hankins, D.E., Los Alamos Scientific Laboratory, Los Alamos, NM. 1974, February

Progress in Personnel Neutron Dosimetry. CONF-730907 (Part 1); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 515-527), 1475 p.

The paper reviews recent progress in personnel neutron dosimetry. A survey of the various albedo-neutron dosimetry systems that have been developed shows the advantages and disadvantages of each of the systems. The energy dependence of the albedo-neutron dosimeters is rather poor, and the effect of this on their accuracy and usefulness is discussed. Fission-fragment damage to polycarbonates has been studied extensively, with most investigators using the spark-counter technique for evaluation. A survey is made of the systems currently in use, and the problems associated with their use are discussed, including sensitivity, evaluation time, and exposure of the wearer to the fissionable material. At present, three U.S. laboratories are known to be routinely using fission-track dosimeters on personel. Argonne National Laboratory is using a U 235 system with mica foils. Brookhaven National Laboratory is using thorium and a polycarbonate foil and Oak Ridge National Labortory is using a finger ring of thorium and polycarbonate foil, with spark counting for evaluation. Other systems under study but not yet in practical application are discussed briefly and include thermally stimulated exoelectron emission (TSEE), direct response of thermoluminescent-dosimeter (TLD) materials to fast neutrons, and the response TLD materials to recoil protons. (Auth) (FMM)

<412>
Hardy, E.P., Jr., Health and Safety Laboratory, Environmental Studies Division, New York, NY. 1974, October 1

Fallout Program Quarterly Summary Report, June 1, 1974 through September 1, 1974. HASL-286; 169 p.

The report presents current data from the Health and Safety Laboratory (HASL) Program, The Institute of Nuclear Science in Taiwan, and the National Radiation Laboratory in New Zealand. Three articles have been selected for inclusion in the data base. The initial section consists of interpretive reports and notes on depth distribution of artificial radionuclides (Sr 90, Cs 137 and Pu 239, 240 in soil, alpha contribution to beta background, global deposition of Sr 90 through 1973, fallout plutonium 239, 240 in diet, strontium 90 in human bone, sediment sampling near Mound Laboratory to obtain information about the geochemical behavior of Pu in a freshwater system and ocean vs. land strontium 90 fallout. Subsequent sections include tabulations of radionulide levels in fallout, surface air, milk, diet, and tap water environmental radioactivity surveys from nuclear power plants in North Taiwan and environmental radioactivity surveys from New Zealand. A bibliography of recent publications related to radionuclide studies, is also presented. (Auth) (FMM)

Part 1, Table 1, shows fallout Pu 239, 240 in food in New York in 1972. Part 3, Table 8 shows the total beta activity, U, and Sr 90 concentration in well water at Chienhua, Taiwan.

<413>
Healy, J.W., and W.J. Smith, Los Alamos Scientific Laboratory, Los Alamos, NM. 1974, September

Contamination Limits for Real and Personal Property, Progress Report for the Period of January-June, 1974. LA-5726-PR; 5 p.

A progress report summary is given for work performed at Los Alamos Scientific Laboratory to establish contamination limits for real and personal property. Primary attention was devoted to the question of surface contamination and transfer of this contamination to the body or other objects. Models, however general, must be derived for the uses of the various types of objects of

<413> CONT.
interest, and these must be related to transfers of contamination and resulting modes of contamination. Work continued on application of the equations and program for the Wang 600 calculator in describing the response of the FIDLER to various configurations of plutonium and americium in soils. A review of a petition on plutonium limits by the Natural Resources Defense Council and a summary of comments on the proposed soil standard for plutonium are included. (BBM)

<414>
Healy, J.W., and W.J. Smith, Los Alamos Scientific Laboratory, Los Alamos, NM. 1974, July

Contamination Limits for Real and Personal Property. WASH-1332; CONF-740406; Part of Proceedings of the 2nd AEC Environmental Protection Symposium held in Albuquerque, New Mexico, April 16-19, 1974, Vol. 2, (p. 705-713), 1151 p.

The project on derivation of contamination limits applicable to real or personal property was initiated to propose and justify operation limits which apply to the release or sale of property which has been used in work areas where radioactive materials are present. The initial effort in this study was a derivation of a proposed standard for plutonium in soils. In general, the maximum permissible body burden derived at the Chalk River Conference and revised for non-occupational exposure and the ICRP-NCRP value for dose to the lung of an individual was adopted. The primary mode of plutonium intake from soils is inhalation. Considerable attention was paid to resuspension from the soil by atmospheric dispersal and deposition and mechanical disturbance. A very crude model was derived to describe particle deposition as a function of wind speed, particle size, surface roughness and atmospheric stability. Localized resuspension was estimated by using the "resuspension factor" although it is not completely satisfactory. The recommended interim standard for plutonium in the soil proposed is 500 dpm per gram in less than 100 um particle size. A limitation of a total of 1000 dpm per gram in all particle sizes should limit production of small sizes by weathering. This standard is out for review and comment. As a result of the resuspension study and the need to derive resuspension rates from reported data, theoretical investigation of response characteristics of the FIDLER instrument for Pu and Am distributed in the soil profile was started. (BBM)

This report is based on LA-5482-MS, "A Proposed Interim Standard for Plutonium in Soils," J.W. Healy, 1974.

<415>
Herceg, J.E., and L.J. Johnson, Los Alamos Scientific Laboratory, Los Alamos, NM. 1973

The Los Alamos Scientific Laboratory's Environmental Monitoring Program: An Overview with Emphasis on Environmental Dosimetry. CONF-731101; Part of Proceedings of the Joint Meeting of the American Nuclear Society and the Atomic Industrial Forum and Nuclear Energy Exhibition held in San Francisco, California, November 11-15, 1973. Published in Transactions of the American Nuclear Society, 17, 541-542.

The Los Alamos Scientific Laboratory's environmental monitoring program consists of several routine and special subprograms aimed at measuring both the concentrations of various constituents in air, water, sediments, and soils and the levels of external radiation in the Los Alamos environs. Atmospheric samples were collected weekly, and 1972 analyses revealed total alpha, beta, and gamma activities. Iodine 131, total uranium, plutonium 239, and americium 241 were at normal levels for worldwide fallout in the northern atmosphere, but tritium and plutonium 238 were somewhat elevated in the immediate laboratory environs. All radioactive constituents from water samples were attributed to natural occurring species and worldwide fallout. (BBM) (CTS)

Data on amounts of Pu were not given but may be found in report, LA-5184.

<416>
Imai, T., and M. Sakanoue, Kanazawa University, Radiochemical Laboratory, Department of Chemistry, Kanazawa, Japan. 1973, April

Content of Plutonium, Thorium and Protactinium in Seawater and Recent Coral in the North Pacific. Journal of the Oceanographical Society of Japan, 29(2), 76-82.

The contents of plutonium isotopes (Pu 239 and Pu 238), thorium isotopes (Th 232, Th 230 and Th 228) and protactinium 231 in seawater collected in the North Pacific (1970), the East China Sea (1969) and the Japan Sea (1972) were determined. These nuclides were sequentially analyzed by alpha-ray spectrometry after separating them using solvent extraction techniques. The contents of Pu 239 in surface seawater ranged from 0.6 to 1.6 pCi/1000 l, Pu 238/Pu 239 activity ratios being 0.2 to 0.7. The Th 228/Th 232 activity ratios for the North Pacific waters varied between 7.6 and 30, whereas the sample from the East China Sea showed the very high value, 65. The contents of Pa 231 were less than 6% of that in equilibrium with its parent U 235. The analysis of plutonium isotopes in recent coral from Yoron Island was carried out and it was confirmed that plutonium isotopes have concentrated in recent coral with the concentration factor of about 1 to 2 x 10(E+3). (Auth)

<417>
Kleinman, M.T., and H.L. Volchok, Health and Safety Laboratory, Environmental Studies Division, New York, NY. 1970, April 1

The Quality of Radiochemical Analyses in the Health and Safety Laboratory Surface Air Sampling Program During 1968. HASL-224; Part of Hardy, E.P., Jr., Fallout Program Quarterly Summary Report, December 1, 1967 through March 1, 1970, (p. I-9 - I-13), 144 p.

Radiochemical analyses for the surface air sampling program during 1968 were performed for the Health and Safety Laboratory (HASL) by Tracerlab, Inc. Three quality control samples are submitted along with each monthly shipment. Results were tabulated for analyses of the blanks for each radionuclide. In general, these data indicated low levels of contamination for most radionuclides, however the average Pu 238 blank rose from 0.04 dpm in 1967 to 0.22 dpm in 1968. Because the amount of Pu 238 found in surface air samples is frequently in the range of 1 dpm, this blank may represent a significant

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<417> CONT.
fraction of the total activity and there appears to be a large positive bias in Pu 238 values for 1968. Samples submitted to the contractor in 1969 were prepared with a new standard solution and do not exhibit this bias. It is probable that the poor results reflect a degeneration of the Pu 238 standard solution used for preparation of the 1968 quality control samples. (BBM)

<418>
Kloke, A., and F. Ludwieg, Institut fur Nichtparasiture Pflanzenkrankheiten, Biologische Bundesanstalt fur Land und Forstwirtschaft, Berlin, German Federal Republic. 1962

Strontium 90, Cesium 137, and Plutonium 239 in Hay Samples from 1953 to 1961. Naturwissenschaften, 49, 65-66.(German, English Summary)

The Sr 90, Cs 137, and Pu 239 content in hay samples was determined from 1953 to 1961 in 2 locations. Some Sr 90 and Cs 137 was detectable in 1953, it increased greatly from 1954 to 1955, then decreased slightly again. Peak values were obtained in 1958 and 1959. Fluctuations in content corresponded to the fluctuations of the two other radionuclides. Peaks of Pu 239 were reached in 1958 and 1959 with 5 to 6 pCi/100 g hay. The Cs 137/Sr 90 ratio decreased considerably from 1953 to 1961 due to preferred root uptake of Sr 90. (RAF)

<419>
Knox, J.B., H.A. Tewes, T.V. Crawford, and T.A. Gibson, Jr., Lawrence Radiation Laboratory, Livermore, CA. 1970, March 2

Radioactivity Released from Underground Nuclear Detonations: Source, Transport, Diffusion, and Deposition. UCRL-50230 (Rev. 1); 111 p.

Lawrence Radiation Laboratory's K Division is capable of predicting both the close-in external gamma radiation field produced by a subsurface nuclear explosion and the concentration of airborne radionuclides at long ranges, including changes in the diffusion of the cloud. The report presents the basis of and the most recent results from the computational physics models of the radionuclides produced (the source), the transport and simultaneous lateral eddy diffusion of the radionuclides initially in the stabilized cloud (the KFC model), the development of the main nuclear cloud (the GEM and TENSOR models), and the tow-dimensional atmospheric diffusion of the initial cloud through a time and space dependent diffusion environment (the 2 BPUFF model). The calculated results have been compared to observed data in order to develop estimates of reliability as well as indications of key areas that need further investigation. Seven chapters of the report were selected for inclusion in the data base. (Auth) (CTS)

<420>
Krey, P.W., R.E. Fried, and R.J. Schultz, Isotopes, Inc., Westwood, NJ. 1965, August 23

Operation Roller Coaster, Project Officers Report, Project 2.3. Fallout Collection. POP-2503; WT-2503; 106 p.

Integral and time differentiated incremental fallout collectors were exposed after each of the four Roller Coaster events. Each collector exposed a sticky film, two microscope slides, and a planchet. The planchets were alpha radioassayed in the Project 5.1a field laboratory and served as an index for those stations which sampled significant fallout. The sticky films and microscope slides selected for subsequent radiochemical analysis and special particulate studies, respectively, were chosen on the basis of the planchet radioassay. Deposition contours derived from planchet activities are given. Soil cores were taken before and after each event to represent high, intermediate, and low-level deposition areas. Only the 0- to 1/2-inch fraction of the core was reserved for subsequent analyses. (HP)

Permission received June 20, 1975, via phone conversation with Project Officer, P.W. Krey, to enter as a declassified document rather than as originially classified as Official Use Only (CTS).

<421>
Lippmann, M., New York University, Institute of Environmental Medicine, New York, NY. 1972

Respirable Dust Sampling. Part of Air Sampling Instruments for Evaluation of Atmospheric Contaminants, Fourth Edition, (p. G-1 - G-16), 558 p.

Techniques of sampling for the evaluation of the toxicological insult arising from the inhalation of airborne particles are discussed. The hazard from airborne particles varies with their physical chemical and/or biological properties. There are a number of major subdivisions within the respiratory tract (nasal passages, pharynx, larynx, tracheo-bronchial tree, alveolar region) and the structure, size, function and different mechanisms for particle elimination are discussed for these. Estimates of regional deposition based on living model calculations are given. Various standards and definitions for respirable dust are discussed such as the standards of the British Medical Research Council, U.S. Atomic Energy Commission, American Conference of Governmental Industrial Hygienists and British Occupational Hygiene Society. A variety of acceptable instruments for sample collection has been proposed, with alternative specific indice of concentration for each instrument. Basically there are two sampler acceptance curves described and they have similar but not indentical characteristics. Instruments for size-selective sampling are described, such as two-stage and multi-stage samplers. The latter are designed to simulate deposition within more restricted subdivisions of the respiratory tract. The limitations of selective sampling and selective samples are discussed and the application of the instruments are described. (FMM)

<422>
Machta, L., and K. Telegadas, Environmental Science Services Administration, Silver Spring, MD. 1970

Radiodine Levels in the U.S. Public Health Service Pasteurized Milk Network from 1963-1968 and their Relationship to Possible Sources. Health Physics, 19, 469-485.

Meteorological analysis of the paths of nuclear clouds has been used to assign the source of radioiodine in the milk samples collected in the U.S. Public Health Service

<422> CONT.
Pasteurized Milk Network (PMN). Most of the instances of elevated values between April 1963 and December 1968 are attributed to six atmospheric nuclear explosions in western China. Only one of five cratering events at the Nevada Test Site (i.e. Palanquin) caused elevated values in the PMN milk. Two periods with relatively low concentrations of radioiodine in milk possess no apparent explanation. By selecting periods with no atmospheric or cratering events, it is argued that at most small amounts of radioiodine in the PMN can be attributed to accidental releases from underground nuclear tests in the United States during the period of analysis. Radioiodine from accidental releases, reactor tests, and cratering events has been detected in a local raw milk network surrounding the Nevada Test Site. (Auth)

<423>
Nelson, I.C., Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1968; 1967, May 9

Theoretical Excretion of Plutonium in Urine Based on the New ICRP Lung Model. BNWL-SA-1247; CONF-670521, Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 266-278), 680 p.

The new ICRP lung model is a significant advance in establishing a rational basis for internal depositions from inhalation of radioactive aerosols. In the case of plutonium nitrate and plutonium oxide, estimates of lung and systematic burdens can be made from urine or fecal analysis for plutonium if the particle size distribution is known. Less satisfactory, but in some instances adequate, estimates of lung and systemic burdens can be made at long times after intake without particle size data. Data from urinary excretion of plutonium are adequate to estimate systemic burden regardless of particle size at about one month after intake for plutonium nitrate and at about one year for plutonium oxide. Carefully performed analysis of feces for plutonium offers considerable increase in sensitivity over the urinalysis method for the estimation of lung burdens. The estimation of body burdens by analyses of body excretion for plutonium has been strictly theoretical and assumes the new lung model to be accurate in all respects. In the absence of experimental evidence to the contrary it is recommended, however, that these excretion results be used in the assessment of internal depositions. Because of the large dependency on particle sizes, estimates of lung and systematic burden require better characterization of the air inhaled by the worker. (Auth)

<424>
Nielsen, J.M., and T.M. Beasley, Hanford Laboratories, Chemical Laboratory, Richland, WA. 1964

Radiochemical Determination of Plutonium for Radiological Purposes. CONF-448; STI/PUB/84, Part of Proceedings of a Symposium on the Assessment of Radioactive Body Burdens in Man held in Heidelberg, Germany, May 11-16, 1964, Vol. 1, (p. 245-260), 1043 p.

In this paper the procedures that have been and are currently being used for the determination of micro-microgram quantities of plutonium in biological and environmental samples are reviewed. Special emphasis is placed on excretion analysis. Expected urinary excretion rates have been calculated, using assumed levels of plutonium deposition, so that the analytical sensitivities of various procedures can be compared. Complete dissolution of excreta, soil, bone, tissue and vegetation are described with emphasis on avoiding the formation of refractory compounds of plutonium which are soluable with difficulty. Analytical methods for plutonium analysis of these materials are reviewed and include co-precipitation, liquid-liquid extraction, ion exchange chromatography and the use of plutonium isotopes for yield determination by means of alpha energy analysis. Using counting statistics, comparisons are made of the sensitivities available in low-level alpha counting, using ionization chambers, proportional counters, diode counters, and nuclear track emulsions. Isotopic analysis of plutonium by alpha spectrometry, nuclear emulsion techniques, and liquid scintillation counting are included. The use of non-isotopic carriers as a source of extraneous activity and the environmental levels of plutonium recently encountered around the world are discussed in connection with "blank" samples. Two possibilities are considered for future methods of plutonium analysis where increased sensitivity is required. These are activation analysis and fission fragment counting. (Auth)

<425>
Not given, International Atomic Energy Agency, Vienna, Austria. 1974

Environmental Surveillance Around Nuclear Installations. CONF-731117; STI/PUB/353, Proceedings of a Symposium on the Environmental Surveillance Around Nuclear Installations held in Warsaw, Poland, November 5-9, 1973, Vols. 1-2, 470 p.

Two-hundred participants from 26 member states and 8 representatives of international organizations participated in a symposium in Warsaw sponsored by the IAEA and the government of Poland. Sixty-one papers were presented covering the objectives of environmental surveillance, preoperational investigations, environmental monitoring procedures in normal and emergency situations, the interpretation of results, research and supportive studies, and examples of the environmental surveillance programs conducted at specific installations. A small number of papers dealt with non-radioactive contaminants. Three papers dealt with the problems arising in the establishment of standards and derived working limits and the operation of adequate environmental surveillance systems for both radioactive and non-radioactive contaminants that might be released to the environment in the nuclear industry. It was emphasized that clear objective should be set for any environmental surveillance programs in order to avoid waste of resources in manpower and equipment. Six articles were selected for input into the Data Base. (RAF)

<426>
Not given, Dow Chemical Company, Rocky Flats Division, Golden, CO. 1973, April 11

Errata: Annual Report: Environmental Safeguard, 1971. RFP-ENV-71B (Errata); 17 p.

<426>

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<426> CONT.
The Rocky Flats Division annual environmental report, (RFP-ENV-71B) Annual Report: Environmental Safeguards 1971, March 10, 1972 contained several tabular and typographical errors. These errors, although insignificant in terms of compliance with existing environmental guidelines, are inconsistant with the high degree of accuracy in reporting environmental surveillance activities. The report represents pages 15 though 31 of RFP-ENV-71B as corrected. The entire tabular summation of that report is herein reproduced, including data correct as stated and corrections where necessary. The noted corrections are the result of a complete recomputation of totals, averages, percent of standards and summations. The accompanying changes in text are also included. The tabular data represents sampling at various locations on and off site for radioactive and nonradioactive stack effluent releases; average monthly radioactive air sample concentrations on and offsite; special high volume radioactive air samples; average monthly beryllium concentrations in air samples on and offsite; dustfall sample summary; water surveys; yearly summation of sediment samples; surface soil analyses, offsite contours; and vegetation samples. Surveys were conducted for plutonium, uranium, and other long-lived particle releases. (BBM)

Corrections to the text and tabular data are given for RFP-ENV-71B, Annual Report: Environmental Safeguard, 1971, March 10, 1972.

<427>
Not given, Health and Safety Laboratory, New York, NY. 1973, May

Surface Air Sampling Program, 80th Meridian Network, January through December, 1970. Radiation Data and Reports, 14(5), 307-312.

The Health and Safety Laboratory Surface Air Sampling Program studied spatial and temporal distribution of nuclear weapons debris and lead in surface air. Samples were taken at 21 locations in the western hemisphere from January to December 1970 and sent to Trapelo Division, Richmond, California. Emphasis was given to determination of manganese 54, iron 55, strontium 90, cadmium 109, cesium 137, cerium 144, plutonium 238 and 239. Concentrations for these radionuclides were tabulated for each month of the year and each reporting station. The longer lived fission products and plutonium 239 concentrations should describe the general distribution in surface air in all previous nuclear weapons debris transfered from the lower stratosphere to the troposphere during this collection period. Most of the plutonium 238 was disseminated to the stratosphere during the reentry burnup of a SNAP-9A power source in 1964 which released about 17,000 Ci of Pu 238. (BBM)

<428>
Peterson, C.M., University of Minnesota, School of Public Health, Minneapolis, MN. 1972

Aerosol Sampling for Particle Size Analysis. Part of Air Sampling Instruments for Evaluation of Atmospheric Contaminants, Fourth Edition, (p. F-1 - F-11), 558 p.

The meaning of the terms particle and particle size is discussed and the theory and sources of error in sampling as well as the basics of presenting and interpreting particle size data are described. The term "particle" is defined as a small discrete mass of solid or liquid matter. Particles are generally defined according to shape as to one of the following categories: spherical, irregular-cubical, flakes, fibrous or condensation flocs (aggregates). Depending on the specific sampling objectives and the nature of the aerosol the sample may be drawn from a dynamic air stream or from a near static cloud. In this regard, the state of the aerosol must be considered with respect to the air stream velocity, relative concentration of particulates, chemical and physical nature of the gaseous system, and the possibility of time dependent variations. The physical processes of sampling and transporting aerosols are complicated by several factors, many of which tend to bias the sample. Particle sampling and subsequent sizing errors of this type are labeled sampler bias, and are defined defined as the volumetric particle concentration or size distribution determined from the probe sample divided by the actual array of particles which existed in the aerosol cloud. The average primary factors affecting sample bias can be combined in different ways to yield several dimensionless groups to predict sampling errors. The most important of these various groups of parameters are the inertial impaction parameter and the velocity ratio. Particles of an aerosol will be heterogeneous in size and hence when such particles are measured the results are best presented and studied by statistical methods. To show the difference between presenting and interpreting number-size data by the two common means of classification (linear versus logarithmic), a hypothetical sample of particle number-size data is presented. It is of paramount importance that all data reviewed for a specific purpose be analyzed as per a standard method and properly designated as to what the method is. (FMM)

<429>
Platt, R.B., J.M. Palms, H.L. Ragsdale, D.J. Shure, P.G. Mayer, and J.A. Mohrbacher, Emory University, Department of Biology, Atlanta, GA; Georgia Institute of Technology, Atlanta, GA. 1973

Empirical Benefits Derived from an Ecosystem Approach to Environmental Monitoring of a Nuclear Fuel Cycle Reprocessing Plant. CONF-730503; STI/PUB/345; IAEA-SM-172/31; Part of Proceedings of a Symposium on Environmental Behavior of Radionuclides Released in the Nuclear Industry held in Aix-en-Provence, France, May 14-18, 1973, (p. 673-700).

The environmental monitoring program for a nuclear fuel reprocessing plant (Allied-Gulf Nuclear Services) located in the South Carolina coastal plain, is based on a man-environment ecosystem concept. Impact measurement and analysis capabilities include radionuclides, noxious chemicals and heat. The principal pathways to man, atmospheric, terrestrial and aquatic, are each subdivided into natural, recreational and domestic components. Basic inputs include meteorology, geology, surface drainage, direction and velocity of groundwater flow, interaction of underlying aquifers and ecological descriptions of the various interrelated ecosystems of the site and region. Process water is discharged through an ecological monitoring, conditioning and cooling pond. Sampling from a 100 square mile grid is based on significant links in the various ecological pathways. Standardized procedures for sample

<429> CONT.
collection, processing and analysis have been developed. All data may be stored, retrieved and analyzed through an open computerized program, designed so that additions can be made and data verified and retrieved under any ordered scheme for either printed or graphic display. Empirical benefits include a means for merging results of basic research on distribution and fate of radionuclides, noxious chemicals and heat in the natural environment with monitoring activities, based on direct and indirect pathways to man. The use of ecologically defined samples provides rates of movement and bio-accumulation that (a) are sensitive enough to verify the adequacy of source control with respect to environmental quality, (b) indicate magnitudes and trends of ecological impacts and therefore serve as an early warning system of potential adverse effects to the environment and man before they become irreversible or expensively reversible, and (c) provide a base for comparison with measurements and analyses of effluents from other sources on a regional and international scale. The program can accommodate additional questions from other sources on a regional and international scale. The program can accommodate additional questions and unexpected impacts. The procedures and ecological models are transferable to other nuclear industry. Thus, through the characteristics of comparability, accommodation, predictability, and transference, the program emphasizes those basic factors and procedures that are necessary for determining the capacity of the environment to receive radionuclides, with emphasis on both natural and human radiation exposures. (Auth)

<430>
Ramsden, D., and R.G. Speight, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Dorset, England. 1968

The Measurement of Plutonium 239 In Vivo, A Progress Report. CONF-670521, Monographs on Nuclear Medicine and Biology, No. 2, Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 171-188), 680 p.

A prototype monitoring equipment, consisting of a low background xenon-filled multiwire proportional counter, used in conjunction with a large area thin-windowed sodium iodide crystal, has been developed for the measurement in vivo of the lung content of insoluble Pu 239 at the Atomic Energy Establishment, Winfrith. The equipment has been used to make measurements on a small number of subjects with lung burdens of Pu 239 around or in excess of the present detection limit of about 0.012 uCi. Calibration factors for the detectors under different geometric conditions have been obtained by using a realistic chest phantom. The equipment and techniques are detected and the many sources of error inherent in such measurements are discussed. A number of refinements are suggested. It is proposed to modify the design of counters and to make some alterations in technique. The resulting system will be suitable for routine use and it will enable the detection insoluble Pu 239 lung burdens down to a level of about 0.008 uCi. Modifications to the phantom will primarily consist of incorporating the results obtained by the use of ultrasonics on normal subjects. The introduction of homogenous impregnated lungs and a liver section is intended. A system is described which is primarily intended to reduce the counting time for complete examination of a subject at 40 min. and enable a routine examination procedure for people 'at risk' to be established. (FMM)

Figure 8A shows a schematic plan of new equipment--whole body monitor. Figure 4 shows the calibration chest phantom assembly.

<431>
Soldat, J.K. (Ed.), and T. H. Essig (Ed.), Battelle Memorial Institute, Pacific Northwest Laboratories, Environmental Health and Engineering Department, Richland, WA. 1966, September

Evaluation of Radiological Conditions in the Vicinity of Hanford for 1965. BNWL-316, 32 p.

During 1965, the environmental surveillance program of the Hanford environs showed that the amounts of radioactive materials present were well within nationally accepted limits at all times and that releases of radioactive wastes were well controlled. Phosphorus 32 released to the Columbia River in reactor effluent continued to be the most significant source of radiation from the Hanford project. This P 32 is concentrated by fish that inhabit the river downstream from the reactors. Individuals who regularly eat such fish as a major part of their diet throughout the year could conceivably have taken in as much as 11% of the annual permissible amount of this bone seeker. Iodine 131 in the Hanford environs remained at very low concentrations in 1965. The Chinese nuclear test on May 14 caused a brief increase in I 131, but concentrations soon returned to the low levels experienced during most of 1965. The postulated "maximum" annual dose from I 131 to the thyroid of a small child amounted to only about 4% of the Radiation Protection Guide recommended for individuals by the Federal Radiation Council. The estimated whole body dose of the average Richland resident from nuclides of Hanford origin was 5 mrem. Whole body doses from natural background and fallout sources in this region are estimated at about 110 mrem/yr and 2 mrem/yr, respectively. (FMM)

Table 2 shows annual average concentration of several radionuclides in Columbia River water in 1965, (including Np 239).

<432>
Swinth, K.L., Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1967, April 14, 1968

Interpreting Counting Data for Internally Deposited Plutonium. BNWL-SA-997, CONF-670521, Monographs on Nuclear Medicine and Biology,, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 209-221), 680 p.

Rapid indications of inhaled amounts of plutonium at levels near the Maximum Permissible Body Burden (40 nCi) are possible with the equipment described. This equipment, coupled with the enhancement of sensitivity by radiations from the rapidly eliminated portion of the inhaled material, will yield information on exposed individuals who may have a retained body burden constituting a fraction of an MPBB. The

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sensitivity can be enhanced by a factor of five but this enhancement is variable to a degree depending on exposure conditions. The accuracy with which a body burden estimation can be made by in vivo x-ray counting is discussed. As the data and calculations have indicated, the use of Am 241 as a tracer is less affected by the many variables present and should yield greater sensitivity for many isotopic compositions. The use of Am 241 as a tracer requires one to assume that the translocation rates of Am 241 and plutonium are the same for counting to be performed after a significant lapse of time following an exposure. Because of the great sensitivity of the scintillation counter and the ability to efficiently count both the x-rays and Am 241 gamma rays, the use of these counters appears more promising than other methods. Proportional counters and, in the future, solid state detectors are excellent for high-resolution x-ray detection and low background rates, but the problems in interpretation of data still exist. Whole body count data compares favorably with data obtained from bioassay methods. (PHM)

<433>
Borasky, R., and D.H. Willard, Hanford Atomic Products Operation, Richland, WA. 1958, Janua 10

Electron Microscopy of Aerosols Containing Radioactive Particles. HW-53500; Part of Kornberg, H.A., Hanford Biology Research Annual Report for 1957, (p. 167-171), 226 p.

This report presents the electronioscopic appearance of particles from three aerosols containing Sr 90, SO4, Ru 106 RuO2, or Pu 239 PuO2. Three types of Sr particles were observed, needles, needle clusters and spheroid particles. Practically all of the Ru particles were three dimensional chain aggregates of nitrate spheroid particles. Plutonium particles were predominantly individual units of dense cubic particles; aggregates rarely consisted of more than five units. (FAF)

Photographic enlargements of electron micrographs of Sr, Pu and Pu aerosols are given.

<434>
Glasstone, S., Los Alamos Scientific Laboratory, Los Alamos, NM. 1967

Sourcebook on Atomic Energy. D. Van Nostrand Company, Inc., Princeton, New Jersey, 3rd Edition; 883 p.

The reference book describes in simple language, with a minimum or mathematics, the most important developments in those areas of science covered by the general term "atomic energy". The historical approach has been used whereever possible. The chapters include some of the following topics: foundations of the atomic theory, the structure of the atom, natural radioactivity, detection and measurement of nuclear radiations, nuclear fission, the utilization of nuclear energy, nuclear reactors, the synthetic elements (describing the discovery and properties of Np, Pu, Am, Bk, Cf, Cm and other transuranium elements), the uses of isotopes and radiations, biological effects and radiation protection and cosmic rays. At the end or each chapter, a list is given of books and articles suitable for further reading. (FNM)

<435>
Horst, T.W., J.G. Droppo, and C.G. Elderkin, Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1974, April

An Assessment of the Long-Term Exposure Due to Resuspension. BNWL-1850 (Part 3), Part of Simpson, C.L., et al (Eds.), Annual Report for 1973, (p. 223-227), 284 p.

A simple model of the interaction between an airborne pollutant and the underlying surface is postulated which includes the processes of deposition, fixation by the soil, resuspension and redeposition. This model is used to calculate the ratio between the exposure to the resuspended material and the exposure to the primary material. Utilizing current estimates of model parameters, this ratio could range from 5 to 10(E-4). In the case where resuspension is locally balanced by redeposition, however, this range is narrowed to 0.5 - 0.05. Horizontal homogeneity is a sufficient condition for this balance to hold true. (Auth)

<436>
Slinn, W.G.N., Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1973, April

Initial Resuspension Models. BNWL-1751 (Part 1), Part of Simpson, C.L., et al, Annual Report for 1972, (p. 5-15), 152 p.

A progress report is presented of efforts made to understand the resuspension of aerosol particles from the earth's surface. It is seen that for u sub * = 20 cm sec (E-1), (where u is the kinematic viscosity of the air) horizontal wind fluctuations can dislodge most sub-millimeter particles from dry soil. This suggests that the soil particle size distribution is the controlling factor of the airborne particle size distribution in the near-surface layer. Above the surface layer, it is shown that the convective diffusion equation is incapable of explaining experimental data. A statisitcal approach based on the probability distribution of vertical wind speeds is explored and it is shown that observed wind speed data dose correctly describe the size distribution of large, resuspended particles. Directions are indicated for future theoretical and experimental studies. (Auth)

<437>

PRODUCTION

<437>
Christ, R., and B. Schulz-Forberg, U.S. Atomic Energy Commission, Washington, DC. 1974

Development and Testing of Overpack-Constructions Based on Phenolic Foam Walls. CONF-740901 (Part 1); Part of Proceedings of the 4th International Symposium on Packaging and Transportation of Radioactive Materials held in Miami Beach, Florida, September 22-27, 1974, (p. 207-216), 1195 p.

An overpack system was developed for the shipment of liquid and solid plutonium-containing wastes. A phenolic foam was selected for its shock-absorbing and insulating qualities, its ease of handling and economy. In the design of the overpack thickness attention was given to avoid boiling of liquids under fire conditions. The foam specifications were chosen on that basis. To prevent deformation, the inner container in the drumhead area was specially constructed. Up to date no problems were encountered during loading, transport and unloading. (PAF)

<438>
Moulthrop, H.A., and J.L. Femp, Atlantic Richfield Hanford Company, Richland, WA. 1971

Description of Atlantic Richfield Hanford Company's New Compact Plutonium Storage Facility. CONF-710401; Part of Proceedings of the Rocky Flats Symposium on Safety in Plutonium Handling Facilities held in Golden, Colorado, April 13-16, 1971, (p. 56-67), 457 p.

A new plutonium storage facility has been constructed at Richland which uses a shielded cubicle arrangement for reducing radiation dose rates. Reduction in radiation exposure by a factor of ten is expected in the vaults from that experienced in plutonium storage vaults previously used. A products-of-combustion fire detection system throughout the facility and a sprinkler system in the scrap storage area provides continuous fire protection. A preliminary emphasis is placed on fuel reduction with all concrete construction. Compartmentation within cubicles reduces the amount of plutonium exposed to combustion if a fire should occur. A storage density of 2.1 spots per square foot is realized for the overall facility. The engineered construction of interconnecting precast concrete panels to form the basic structure and the shielded storage cubicles provides increased safety at decreased unit cost. (Auth)

<439>
Not given, U.S. Atomic Energy Commission, Division of Technical Information Extension, Oak Ridge, TN. 1968, February

Transplutonium Elements: A Bibliography. TID-3317; 53 p.

Part 1 of this bibliography comprises 332 pulbications dealing with the production of and the physical and nuclear properties of transplutonium elements in the atomic-number range 95 less than or equal to Z less than or equal to 101. Nuclear Science Abstracts, Chemical Abstracts, and Physics Abstracts and other published sources for 1965, 1966, and 1967 were scanned in preparing this bibliography. The references in this part are grouped by element from Am to Md (that is Am, Cm, Bk, Cf, Es, Fm and Md) with appropriate cross references to the various entries. Within each group, the references are arranged chronologically, except for cases in which dates are not known. References covering chemistry primarily were not included for the elements in Part 1. Part 2 covers all references available on the transmendelevium elements from 1957. Journals used were the same as for Part 1. This part covers chemistry as well as production and physical and nuclear properties. References are arranged chronologically. (Auth)

<440>
Not given, U.S. Atomic Energy Commission, Washington, DC. 1974

Fourth Proceedings of the International Symposium on Packaging and Transportation of Radioactive Materials. CONF-740901 (Parts 1-2); Proceedings of the 4th International Symposium on Packaging and Transportation of Radioactive Materials held in Miami Beach, Florida, September 22-27, 1974, 1195 p.

One hundred and one papers were presented at the conference, and twenty-three of them have been abstracted separately for the Data Base. Among the topics covered were regulations (international, federal and state) and safeguards; new package design, contained testing including thermal and impact tests, and quality assurance for the packaging; transport studies, shipments, and the experience incountered such as contamination of vehicles and accidents; nuclear criticality safety; risk assessment, where the danger to the environment was discussed; and transuranium packaging, dealing with design, shelding requirements, radiation levels and transport of packages of Cf 252, neptunium nitrate, Pu nitrate, Pu 239 and U 233. (FNM)

<441>
Salmon, R., J.C. Blomeke, and J.P. Nichols, U.S. Atomic Energy Commission, Washington, DC. 1974

Trends and Projected Shipments in the Nuclear Fuel Cycle Industry to the Year 2000. CONF-740901 (Part 1); Part of Proceedings of the 4th International Symposium on Packaging and Transportation of Radioactive Materials held in Miami Beach, Florida, September 22-27, 1974, (p. 349-364), 1195 p.

Projections of the production, shipment, and accumulation of nuclear fuel, plutonium, and radioactive waste from 1974 to 2000 are presented. The nuclear power reactor complex is assumed to consist of LWRs using enriched uranium and plutonium recycle fueling, HTGRs, and LMFBRs. Installed nuclear electric capacity is taken as 102, 500, and 1200 GW(e) at the ends of calendar years 1980, 1990, and 2000, respectively, with an LMFBR capacity of 200 GW(e) at the end of year 2000. Trends seen in fuel and waste shipping are more stringent recovery of radioisotopes from the effluents of all types of nuclear installations; more emphasis on shipping various types of waste to federal repositories, rather than to burial grounds; continued development of improved shipping concepts; shipment of a greater proportion of spent fuel by rail rather than by truck; and shipment of Pu in the solid oxide form rather than as the nitrate solution. (Auth)(RAF)

<442>
McSweeney, T.I., C.L. Brown, S.W. Heaberline, J. Mishima, R.C. Watson, R.J. Hall, W.S. Kelly, D.K. Davis, S.W. Liu, and L.D. Williams, U.S. Atomic Energy Commission, Washington, DC. 1974

<442> CONT.
Risk Analysis of Shipping Plutonium Oxide and Plutonium Nitrate. CONF-740901 (Part 2); Part of Proceedings of the 4th International Symposium on Packaging and Transportation of Radioactive Materials held in Miami Beach, Florida, September 22-27, 1974, (p. 1172-1184), 1195 p.

This paper demonstrates the application of a model for assessing the risk of shipping radioactive material by analysis of the shipment of plutonium by truck in the form of oxide and liquid nitrate. Transportation system, technical approaches to a systematic analysis and development of probability are described. Analysis demonstrated a significant difference in the risk of shipping plutonium oxide in 6M containers and shipping plutonium nitrate in L-10 containers even though data for probabilities used in the risk assessment were uncertian. The annual risk of shipping Pu in Central U.S. in the year 1980 (expressed as 50 yr dose commitment to organ) for plutonium oxide in 6M was 0.2 and 1.0, and for plutonium nitrate in L-10 0.4 and 4 x 10(E+4), in lung and bone, respectively. (RAF)

<443>
McSweeney, T.T., L.D. Williams, E.C. Watson, J.G. Droppo, D.A. Kottwitz, and R.J. Hall, U.S. Atomic Energy Commission, Washington, DC. 1974

A Risk Assessment Model for Radioactive Material Shipments. CONF-740901 (Part 2); Part of Proceedings of the 4th International Symposium on Packaging and Transportation of Radioactive Materials held in Miami Beach, Florida, September 22-27, 1974, (p. 1100-1117), 1195 p.

This paper presents a method for assessing the risk of radioactive material shipments. An overview of a risk analysis model is given. The type of information to perform the assessment is described. The system components consist of: selection of projected nuclear industry characteristics; material specification, amount, origin, and destination; material characteristics; transport mode and carrier; container and amount of material per container specifications; number of shipments required; and route, restrictions, population, and weather zones. (RAF)

<444>
Ziegler, D.L., Dow Chemical Company, Rocky Flats Division, Golden, CO. 1974

Incineration Process Fire and Explosion Protection. RFP-2210; CONF-740807; Part of Proceedings of the 13th AEC Air Cleaning Symposium held in San Francisco, California, August 12-15, 1974, (13 p.).

Two incinerators will be installed in the plutonium recovery facility under construction at the Rocky Flats Plant. The fire and explosion protection features designed into the incineration facility are discussed as well as the nuclear safety and radioactive material containment features. Even though the incinerator system will be tied into an emergency power generation system, a potential hazard is associated with a 60-second delay in obtaining emergency power from a gas turbine driven generator. This hazard is eliminated by the use of steam jet ejectors to provide normal gas flow through the incinerator system during the 60-second power interruption. (Auth)

<445>
Rubin, J.H., U.S. Atomic Energy Commission, Washington, DC. 1973

The Nuclear Fuel Cycle and Waste Production. CONF-721107; Part of Proceedings of a Symposium on the Management of Radioactive Wastes from Fuel Reprocessing held in Paris, France, November 27-December 1, 1972, (p. 15-36), 1266 p.

The main elements of the slightly enriched water-cooled reactor fuel cycle are described. Included are the operations of: mining and milling, chemical conversion, isotopic enrichment, fuel fabrication, reactor operation, and chemical reprocessing. The nature of the radioactive wastes generated in the various steps of the fuel cycle are characterized. These include: mill tailings, low-level solid wastes, high-level wastes, and low-level wastes containing plutonium and other actinides. Techniques for managing wastes, based on the present level of technology, as well as a view toward possible future alternatives are presented. (Auth)

<446>

RADIATION SAFETY AND CONTROL

<446>
Anderson, R.D., and R.E. Olson, Atlantic Richfield Hanford Company, Richland, WA. 1971

Human Element Design Considerations with Glove Boxes at the Atlantic Hanford Company. CONF-710401; Part of Proceedings of the Rocky Flats Symposium on Safety in Plutonium Handling Facilities held in Golden, Colorado, April 13-16, 1971, (p. 4-16), 457 p.

Important factors which are necessary for the safety, comfort and efficiency involved in glove box work were investigated. Particular effort was expended to define the maximum accessible areas of the human hands when working in glove boxes. A list of basic criteria was established: 1) the maximum accessible area is to be provided for an operator in a standing position, using both hands concurrently in a "clutch-grip" fashion, 2) as near as practical, there is to be 100 percent access to the hood when using one hand at a time, 3) the hoods are to be accessible from the sides with a desirable maximum of two tiers of glove ports, and 4) eye ports should be provided rather than large transparent panels. All equipment mounted within the hoods must be accessible from the glove ports for operation, maintenance, replacement and decontamination. Proper location of viewing windows requires full consideration of work location, reach phenomenon and shielding window depth. (RAF)

Figures 1-3 show diagrams of reach patterns in glove boxes.

<447>
Boucher, F., P. Barthelemy, and C. Milet, Centre d'Etudes Nucleaires, Fontenay-aux-Roses, France. 1972

Safety Studies on Sealed Plutonium 238 Sources for Cardiac Pacemakers. CONF-720519; Part of Proceedings of the 2nd International Symposium on Power from Radioisotopes held in Madrid, Spain, May 29-June 1, 1972, (p. 827-848), 986 p.

In the design in this type of source the main efforts were directed towards cladding in order to obtain optimum containment of the radioisotope. Safety tests performed during these studies are based on: 1) specifications concerning "radioactive materials in special form", 2) recommendations made by the Study Group on Isotopic Batteries of the OECD Nuclear Energy Agency, and 3) additional studies considered necessary for estimating the resistance limits of the sources. The results showed that the sealed capsules developed in these studies present a high degree of safety. (Auth) (RAF)

<448>
Carpenter, G.D., Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA. 1969, January; 1972

Plutonium: Personnel Exposure Control with Increasing Plutonium 240 Content. BNWL-SA-2110; CONF-690103; Part of Willis, C.A. and Handloser, J.S. (Eds.), Health Physics Operational Monitoring, Proceedings of the 3rd Health Physics Society Midyear Topical Symposium held in Los Angeles, California, January 29-31, 1969, Vol. 2. Gordon and Breach, Science Publishers, Inc., New York, New York, (p. 1223-1233), 1848 p.

In recent years there has been a marked increase in the use of commerically recycled Pu in fuel element fabrication programs. Commercially recycled Pu has a higher Pu 240 content than does the Pu which has been available in the past. This higher Pu 240 content results in increased photon and neutron dose rates which are sufficient to require modification of exposure control practices and procedures. This paper discusses some of the modified procedures which have been put to use at the Pacific Northwest Laboratory to effectively maintain personnel dose within the regulatory limits. Recommendatins for controlling personnel exposure are as follows: 1) minimization of fuel quantities and of the total inventory, 2) utilization of photon shields on glove boxes and hoods, 3) constant reexamination of the program, and 4) evaluation of neutron dosimeter calibration. (Auth) (RAF)

<449>
Cottrell, W.B., and A. Klein, Oak Ridge National Laboratory, Oak Ridge, TN. 1974, June

Index to Nuclear Safety, a Technical Progress Review by Chronology, Permuted Title, and Author Vol. 11, No. 1 through Vol. 14, No. 6. ORNL-NSIC-115; 52 p.

Abstracts are included for all articles in this section of the Nuclear Safety Index. Some of the areas covered are siting of nuclear facilities, transportation and handling of radioactive materials, reactor kinetics and sources of energy release under accident conditions, plant safety features, radionuclide release and movement in the environment, environmental surveys, radiation dose to man from radioactivity release to the environment, effects of thermal modifications on ecological systems. and effects of radionuclides and ionizing radiation on ecological systems (RAF)

<450>
Downing, W.E., Dow Chemical Company, Rocky Flats Division, Golden, CO. 1971

Design of Filter Plenum Heat Exchangers. CONF-710401; Part of Proceedings of the Rocky Flats Symposium on Safety in Plutonium Handling Facilities held in Golden, Colorado, April 13-16, 1971, (p. 162-180), 457 p.

A fire test facility was constructed at the Rocky Flats Division of the Dow Chemical Company and consisted of a glove box, protective building and filter plenum. Tests performed within the filter plenum are summarized. Heated air generated by a fire within a radioactive processing building is likely to damage the exhaust filters. The application of water sprays to the face of the HEPA filter banks is likely to result in breakthrough of contamination. Therefore, it is preferable to cool the heated air with a heat exchange prior to filtration. The distribution of the air flow should be uniform so that the contact time within the spray field is maximized for all portions of the air stream. Design parameters for an exchange are subject to uncertainties, and the greatest is the temperature of the inlet air expected from a fire. It appears that the value for the theoretical heat transfer unit is independent of the disengager used, and because of the relatively high inlet temperatures expected, has little effect on the exchanger length required. In order to optimize the heat exchanger design for each filter plenum, it is necessary to determine the exchange inlet temperatures. This can be done by a survey of the combustible material

<450> CONT.
in the area served by the filter plenum, and knowledge of the relative heats of combustion and burning rates. The design can be further optimized for the specific case by considering the effect of dilution air and knowing more accurately the heat loss through the ducting. Based on the assumptions used for the example, which approximates a general case, a heat exchanger length of 5 to 6 feet appeared necessary for protection of the filters for a 1 hour fire. (BBM)

<451>
Douglas, P.L., Southwestern Radiological Health Laboratory, Las Vegas, NV. 1972

Health Physics Program at the Nevada Test Site Experimental Farm. CONF-690103; Part of Willis, C.A. and Handloser, J.S. (Eds.), Health Physics Operational Monitoring, Proceedings of the 3rd Health Physics Society Midyear Topical Symposium held in Los Angeles, California, January 29-31, 1969, Vol. 1. Gordon and Breach, Science Publishers, Inc., New York, New York, (p. 349-360), 1848 p.

The Public Health Service's Southwestern Radiological Health Laboratory has conducted a research program on the Nevada Test Site to study the passage of radioiodine through the forage-cow-milk-food chain. Two types of experiments involved either release of an artifically generated radioactive aerosol or actual fallout contamination of hay. This presentation describes some operational health physics problems which were encountered. A housing trailer is used to change clothes and decontaminate personnel. Equipment is stored in plastic bags or decontaminated. Preparation of the contaminated hay and care of pens and animals are explained. It has been possible to conduct these experiments in which, by normal standards, the radioactivity is relatively uncontrolled. Under the prevailing field conditions, the spread of contamination can be minimized, and judgement is required to determine the degree of contamination control which is reasonable and practical. To date, no significant personnel exposures, internal or external, have resulted from the tests. (BBM)

<452>
Dunning, G.M., U.S. Atomic Energy Commission, Washington, DC. 1968

Observed Fallout Patterns and Countermeasures Taken. CONF-680507; Part of Proceedings of a Symposium on the Radiological Protection of the Public in a Nuclear Mass Disaster held in Interlaken, Switzerland, May 26-June 1, 1968, (p. 29-31), 688 p.

Several incidents resulting in fallout material creating a hazard to the public are cited. The basis for decisions made, the implementation, and results of protective action are recounted. Heavy fallout on the Marshall Islands in 1954 required evacuation of 239 inhabitants. This was accomplished by good capabilities for evacuation and cooperation of the inhabitants. The highest radiation exposure was 175 roentgens. A second incident at St. Georges, Utah in 1953 resulted in a decision to send 4500 persons indoors for a period of 2 hours. The total doses estimated afterwards were not large, yet the circumstances under which the fallout occurred led to the decision. Nearly all 4500 persons were under cover in 15 minutes without panic or injuries because of prior education programs conducted with local officials and the general public. A third incident at Salt Lake City, Utah in 1962 required counter measures by local and state health authorities to reduce iodine 131 content in milk. Cows were placed on dry feed or milk was diverted into milk products. Citizens were alarmed to the point where they switched to dry milk or eliminated milk from the diet. One hundred eighty thousand people were affected, and a lack of understanding of radiation protection guides and the ambiguity of guides resulted in the fear that arose. The incident at Palomares, Spain resulted in plutonium being released from two nuclear bombs and contaminating the immediate area. Tests indicated the total exposure from resuspension after initial deposition to be 5 to 10 rem, but it was feasible to scrape off soil for 2-3 inches and deep plow the area. Two hundred eight-three m3 were stored at the AEC Savannah River Plant. (BBM)

<453>
Egorova, M.S., V.V. Kopaev, L.N. Korzhov, G.M. Parkhomenko, and V.A. Sarycher, Institute of Biophysics, Moscow, USSR. 1974, February

Special Problems in Radiation Safety and Sanitary Dosimetric Monitoring when Working with Transplutonium Elements. CONF-730907 (Part 2); Part of Snyder, W.S. (Ed.), Proceedings of the 3rd International Congress of the IRPA held in Washington, D.C., September 9-14, 1973, (p. 810-813), 1475 p.(Russian)

The factors of radiation exposure at operations with transplutonium elements are in quantitative dependence on the physico-chemical properties, the time of target irradiation in the reactors and the degree of their purification from the fragment fission products. The doses of external and internal irradiation were estimated. (Auth)

<454>
Ettinger, H.J., P.N. Gonzales Mitchell, M., J.D. DeField, and J.C. Elder, Los Alamos Scientific Laboratory, Health Division, Los Alamos, NM. 1974, July

Test Methods and Efficiency Studies on Multi-Bank HEPA Filter Systems. WASH-1332; CONF-740406; Part of Proceedings of the 2nd AEC Environmental Protection Symposium held in Albuquerque, New Mexico, April 16-19, 1974, Vol. 1, (p. 89-147), 1151 p.

Multiple stages of high efficiency particulate air (HEPA) filter banks to attain decontamination factors of 10(E+9) to 10(E+12) are proposed for the LASL new plutonium facility. The AEC design criteria for new Plutonium facilities requires that the filtration system shall be designed to allow reliable in-place testing and ease of replacement. The designs for a glove box filter and a four stage process exhaust filter installation are shown and methods of in-place testing and filter replacement are discussed. While extensive test data are available to substantiate decontamination factors of at least 2 x 10(E+4) for individual HEPA filters against sub-micron laboratory test aerosols, such as DOP, quantitative data for the actual work situation involving plutonium aerosols were not available. A field sampling program provided general criteria defining plutonium aerosol size characteristics and activity concentrations from typical plutonium

<454> CONT.
operations. Using laboratory produced plutonium test aerosols with size characteristics similar to those defined by the field sampling program multiple HEPA filter systems were evaluated to provide quantitative data defining performance of successive stages of HEPA filters, and filter performance as a function of particle size. Test data show that the first and second HEPA filter each provide overall efficiencies in excess of 99.98%, while the third HEPA filter provides an average efficiency in excess of 99.8%. These performance levels exceed AEC requirements. Data defining performance of the first and second HEPA filters as a function of plutonium aerosol size show that HEPA filter efficiencies are in excess of 99.98% for sub-micron plutonium aerosols. (Auth)

<455>
Fisher, F.D., Nuclear Materials and Equipment Corporation, Apollo, PA. 1971

Glove Box Fire-Resistant Materials and Fire Suppression Tests. CONF-710401; Part of Proceedings of the Rocky Flats Symposium on Safety in Plutonium Handling Facilities held in Golden, Colorado, April 13-16, 1971, (p. 17-25), 457 p.

An industry funded, AEC sponsored Ad Hoc Committee has been formed to test and report on glove box window materials and fire suppression systems. The glove box fire resistant materials portion of this study is limited to studies of relative performances of different glazing materials. These are an Argonne National Laboratory type, HAPO type, HAPO Z frame type, and Los Alamos Scientific Laboratory type. Fire suppression systems to be tested will be largely confined to Halone 1301-based systems and will be manually activated. A single report is planned that will serve as a handbook for the industry. (BBM)

<456>
Foster, C.B., and M.J. Szulinski, Atlantic Richfield Hanford Company, Richland, WA. 1974, June 1

Decontamination of Obsolete Processing Facilities at Hanford. ARH-SA-183; 31 p.

An overview is presented of the decontamination work associated with the remodeling of a large fuels processing plant, preparation of a reprocessing plant for stand-by and the dismantling of a Pu scrap processing facility (Recuplex). The best start on decontamination is contamination prevention, and this is initiated during design and operational planning. Planning is also an important ingredient in preparation for decontamination prior to remodeling or deactivating a facility and involves factors of design, operations, and personnel and community relations. At the Recuplex facility the glove boxes were contaminated internally with gross amounts of Pu. These glove boxes and the equipment were cut with a power handsaw to a size which could be loaded into storage boxes and the boxes were sealed and stored by burial in a controlled zone. The surfaces of the room were decontaminated by hand-scrubbing and washing with a detergent until residual Pu was less than 1,000 disintegration/minute per 100 cm 2. The task was completed by repainting with three or four coats of Amercoat. Deactivation of the Recuplex facility demonstrated the feasibility of dismantling major Pu processing facilities in a safe manner with excellent contamination control. (PNM)

<457>
Hulsey, A., General Electric Company, San Jose, CA. 1974

Shielding Requirements for Neptunium Nitrate Shipping Packages. CONF-740901 (Part 2); Part of Proceedings of the 4th International Symposium on Packaging and Transportation of Radioactive Materials held in Miami Beach, Florida, September 22-27, 1974, (13 p.), 1195 p.

As the market for neptunium develops, the likelihood of separating and shipping neptunium increases. To aid the design of a shipping package, a study of the radiation characteristics was performed. Although the radiation from Np 237 is primarily alpha, gamma-rays from daughter products and impurities are significant. As Pa 233 grows in, the gamma intensity increases. The dose rate on the surface of a stainless steel storage bottle increases from about 1.8 R/hr to a maximum of about 3.7 R/hr within 100 days after the neptunium is separated. This dose rate levels off to about 3.5 R/hr after 180 days as a result of Pa 233 reaching equilibrium with Np 237. Shielding studies indicated that some heavy metal was required within the shipping package to attenuate the radiation to acceptable levels. (Auth)

<458>
Jammet, H., D. Mechali, and G. Lacourly, Commissariat a l'Energie Atomique, Centre d'Etudes Nucleaires, Fontenay-aux-Roses, France. 1973

Health Physics Aspects of Nuclear Power Production. CEA-CONF-2513; CONF-730983; Part of Proceedings of the Congress of the Society of Electric, Electronic and Radio Engineers Symposium held in Vittel, France, September 11-15, 1973, (18 p.).(French, English Abstract)

Radioactive pollution from wastes normally or accidentally produced by nuclear installations may result in exposure of certain groups of the population to radioactivity. In normal operation, radiological protection is secured by establishing dosage limits and setting up a monitoring system to ensure their respect. Protection against accident risks is carried out by laying down intervention limits and preparation of emergency plans for limiting the possible damage that might result. (Auth)

<459>
Januska, A.G., W.J. Tyrrell, and G.A. Bennett, Argonne National Laboratory, Occupational Health and Safety Division, Argonne, IL; Argonne National Laboratory, Plant Operations Division, Argonne, IL. 1974, September

Decontamination of Plutonium-Contaminated Glove Boxes

In connection with the Argonne National Laboratory efforts to reduce potential hazards in the event a plutonium use facility was hit by a tornado, a decontamination experiment was carried out to establish the lowest practicable limits of loose contamination in an operating glovebox, and to determine the relative merits of solvent wiping and vacuum cleaning as methods of decontamination. The results showed that a

<459> CONT.
single wiping of the heavily contaminated test glove box Calgon Hel-Cat, Myco Tiara, or Pennwalt 2187 solvent for a short period of time removed greater than 95% of the loose contamination originally present, with a resultant contamination level of 10(E+6) to 10(E+7) dpm/100 cm2. Subsequent wipings had little effect on removing the remaining (less than 5%) contamination. Vacuum cleaning was ineffective as the sole decontamination method; however, this cleaning method was recommended for removing loose plutonium in crevices and other hard-to-wipe areas. These results although limited by the narrow scope of the experiment, offered the possibility of decreased decontamination costs for gloveboxes compared to the standard technique, which required successive wipings until the smears were essentially clean. (Auth)

<460>
Kalmon, E., Goodyear Atomic Corporation, Industrial Hygiene and Health Physics Department, Piketon, OH. 1970, May-June; 1972

Administration of an In Vivo Counting Program. American Industrial Hygiene Association Journal, 31, 353-357; CONF-690103; Part of Willis, C.A. and Handloser, J.S. (Eds.), Health Physics Operational Monitoring, Proceedings of the 3rd Health Physics Society Midyear Topical Symposium held in Los Angeles, California, January 29-31, 1969, Vol. 1, Gordon and Breach, Science Publishers, Inc., New York, New York, (p. 759-771), 1848 p.

Administrative controls of an in vivo counting program as applied to insoluble uranium compounds with the lung as the critical organ are described. Criteria for restricting work activities, and for removal from work restrictions determine the class of restriction. The assumption is made that the effective half-life of insoluble uranium in the lungs is one year until subsequent in vivo data indicate otherwise. If, on the basis of a single in vivo count, the 12 month exposure extrapolated back to the estimated date of uptake exceeds one lung burden, a class 1 restriction is imposed. This involves a work assignment in which the individual is not knowingly exposed to any form of uranium. If the exposure is between 70% and 100% of one lung burden, a class 2 restriction limits the individual to work areas where the average airborne alpha activity is not expected to exceed 15% or less of the plant limit depending on the chemical form of the uranium and the circumstances. Restrictions are in force until subsequent valid in vivo data indicate that extrapolated exposure for 12 months prior to the date of the most recent count is less than the permissible lung burden (0.017 uCi of uranium). The derivation of the lung burden and the weight of U 235 equivalent to one lung burden are presented. Methods and sample calculations of in vivo computation from a specific case are included. (BBM)

<461>
Kleine, F.J., Mound Laboratory, Miamisburg, OH. 1971

Ventilation Systems at Mound Laboratory "PP" Building. CONF-710401; Part of Proceedings of the Rocky Flats Symposium on Safety in Plutonium Handling Facilities held in Golden, Colorado, April 13-16, 1971, (p. 133-148), 457 p.

The purpose of this paper is to supply information on the plutonium processing ventilation systems and major safety projects undertaken at Mound Laboratory in the plutonium processing operation. Should an emergency situation develop, these improvements will assist in maintaining the integrity of the glove boxes and exhaust ventilation systems, and thereby prevent release of radioactive materials. Differential pressures between the ventilation systems are used to restrict the contamination from spreading throughout the system. All air in the building will flow toward the next lower pressure area, and eventually will go to the glove boxes which have a -.65 negative pressure. All air is exhausted out of one of four HEPA filter plenums. The high efficiency air filtration system complies with latest safety requirements recommended for nuclear high-efficiency filtration systems. A Halon 1301 automatic fire detection and protection system was designed and installed for the glove boxes. (BBM)

<462>
Matheson, L.A., T.C. Johnson, and A.J. Oliver, Dow Chemical Company, Rocky Flats Division, Golden, CO. 1971

Air Leakage Into Plutonium Glove Boxes and Its Effect on Inert Operations. CONF-710401; Part of Proceedings of the Rocky Flats Symposium on Safety in Plutonium Handling Facilities held in Golden, Colorado, April 13-16, 1971, (p. 83-97), 457 p.

The Rocky Flats Plant plans to substitute nitrogen for the dried air used in many of the present Pu glove boxes to suppress ignition and burning of Pu metal. Air leakage into glove boxes will increase the oxygen concentration and water vapor, both of which must be controlled. To develop quantitative information on air leakage, an empirical material balance method has been developed to relate air leakage into glove boxes to resultant increases in water vapor or oxygen concentration. This allows estimation of the leakage into glove boxes and also the probable nitrogen requirements. Using water vapor concentration measurements, this material balance method has been applied to a large glovebox system. The analysis of the nitrogen requirements using the water vapor material balance method is described, and other considerations that arise during conversion of a glovebox system to an inert atmosphere. Optimum economic operation will be a balance between extra maintenance and operating labor and the cost of the nitrogen supplied to the system. (RAF)

<463>
Michels, D.E., Dow Chemical Company, Rocky Flats Division, Golden, CO. 1972, July 21

Plutonium Plant Safety. Science, 177(4045), 208-210.

Criticism and comments are made about a report by Dorothy Shapley published in Science on the Dow Chemical Company Rock Flats Division. There was no inconsistancy in saying the population is safe, and more funds are needed to maintain safeness, yet Shapley implied such an inconsistancy. Shapley's principal source on Rocky Flats contamination was E.A. Martell, and while much of his comments have been useful in that they focused attention on the problem, his data and interpretations should be looked at more closely. Duplicate samples at single

<463> CONT.
sites differed by a factor of 6 and 9. Health and Safety Laboratory personnel claimed a method used by Martell abused their data on plutonium contamination offsite. The presumption that equal amounts of plutonium lie in quadrants both southwest and west of the plant was disputed because of wind directions. Offsite contamination and exposure to workers inside the plant are trans-scientific problems, but Shapley seemed to imply DOW is negligent in examining former exposed workers only on a voluntary basis. The plutonium industry is safer now than 15 years ago and will be safer still in 5 years. Asperations in Shapley's report will destort public judgement. (BBM) (CTS)

<464>
Morse, J.L., A.L. Marshall, and A.M. Celoni, Lawrence Radiation Laboratory, Livermore, CA. 1974

In-Residence Health and Safety Support in a Plutonium Facility. CONF-710401; Part of Proceedings of the Rocky Flats Symposium on Safety in Plutonium Handling Facilities held in Golden, Colorado, April 13-16, 1971 (p. 267-279), 457 p.

Health and safety technicians (monitors) provide in-residence safety services to the metallurgical research and engineering effort of the plutonium facility at the Lawrence Radiation Laboratory, Livermore. The paper describes the qualifications of these technicians and typical services rendered by them to the facility scientific personnel, such as, contamination control, waste recovery, monitoring of air sampling equipment, frequent smear and swipe samples, radiation surveys, equipment calibrationand out-processing of liquid and solid wastes to control fire and criticality hazard, etc. (Auth)

The appendix gives an outline of safety indoctrination for plutonium of facility.

<465>
Odland, L.T., P.G. Thomas, J.C. Tashner, H.R. Kaufman, and P.E. Benson, U.S. Air Force Radiological Health Laboratory, Wright Patterson Air Force Base, Ohio. 1968

Bioassay Experiences in Support of Field Operations Associated with Widespread Dispersion of Plutonium. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 256-265), 680 p.

Bioassay experiences associated with the Palomares nuclear accident indicate that, in spite of the many handicaps of field operations, personnel protection and decontamination procedures were effective. The exercise demonstrated that modern communication and transportation facilities permit one well-equipped and staffed laboratory to provide adequate support for an incident of this nature anywhere in the world. Standard USAF procedures were followed to prevent or minimize contamination of personnel by radioactive material. Decontamination of clothes, skin, equipment, etc., was done under field conditions, and prior to departing from the area each individual was isolated for 12 hr, during which time all urine output was collected for bioassay. Of nearly 1,600 participants, less than 20% have a systemic body burden of plutonium detectable by urinary bioassay, and of this number, only 25 showed a value in the range of 7-67% of one permissible body burden. Provisions have been made for long-term follow-up on the group of 25 as well as collection and study of autopsy material as it becomes available. Based on available methods for estimation of systemic body burden of Pu 239 following an inhalation exposure, not one individual who participated in the Palomares operation has demonstrated systemic retention exceeding the maximum permissible amount. (Auth) (RAF)

<466>
Parker, H.M., Not given. 1973

Plutonium, Industrial Hygiene, Health Physics and Related Aspects. Part of Hodge, H.C., et al (Eds.), Uranium, Plutonium, Transplutonic Elements, Chapter 14. Springer-Verlag, New York, New York, (p. 613-667), 995 p.

The broad principles of protection from the predominantly alpha-particle emitting Pu consists in isolating the material from contact with the human body by performing all operations in closed glove boxes with a secondary defense of protective clothing. The environment is protected by filtration of exhaust air from the glove boxes. These protective measures are intended to eliminate inhalation, ingestion, contamination of intact skin and contamination of wounds. Other challenges to health physicists are discussed such as criticality control, environmental releases, and waste storage. The medical management of contaminated person is reviewed and specific methods of treatment of contamination cases, such as by chelation therapy and lavage, are discussed. The origin and purpose of the Transuranium Registry is mentioned. Protection against criticality and protection from external radiations are next dealt with. A summary of Pu internal deposition experience is given, for example, the Stanford experience for 1946-1967 shows 136 cases containing measurable Pu with 15 cases showing deposition about 5% MPBB. Environmental protection for Pu is reviewed with mention made of the sampling and ecological program at the Nevada Test Site, the atomic bomb incidents at Palomares and Thule and the Pu fire at Rocky Flats. A sound waste management program is recommended. In the appendix autopsy data are presented as well as specific cases of interest dealing with Pu deposition. (FMM)

<467>
Raleigh, H.D. (Comp.), U.S. Atomic Energy Commission, Technical Information Center, Oak Ridge, TN. 1973, December

Reactor Safety, A Literature Search. TID-3535-P5-S8; 22 p.

Includes 267 citations to references issued during the period January 1972 through June 1973 on safety aspects of nuclear reactor design, siting, materials, engineered safeguards, and operating procedures. Reports cited concern hazards analyses of entire facilities to satisfy construction and operation permit requirements, evaluation of the reliability of reactor systems and components, and analyses of the consequences of potential accident conditions. Subject, author, corporate author, and report number-availability indexes are included.

<467> CONT.
(Auth)

<468>
Roeder, J.E., Not given. 1968

A Statistical Summary of United States Atomic Energy Commission Licenses' Internal Exposure Experience, 1957 - 1966. CONF-670521; Monographs on Nuclear Medicine and BIology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited RAdionuclides held in Richland, Washington, May 15-17, 1967, (p. 435-450), 680 p.

As part of the AEC Regulatory Program the Division of Compliance inspects materials and facility licenses to ensure that their activities are conducted in a manner which does not result in undue risk to the public health and safety. It is also responsible for the investigation of radiation accidents or incidents. The data presented in this paper are for the period 1957-1966 inclusive. These data, with a few exceptions, are limited to incidents involving the accidental internal deposition of radionuclides which have resulted in a dose to the critical organ equal to or greater than 25% of the recommended annual dose limit for that organ. Chronic exposures are not included. Five cases involving misadministration of radiopharmaceuticals to patients are given. In the cases involving tritium, 5 rems are used as the recommended annual dose limit. A total of 34 cases are given involving tritium, iodine, P 32, Sr 90, In 192, S 35, Po 210, fission gases/corrosion products (Co 60, I 131, I 133, Mo 99, Tc, W 187) mixed fission products (Cs 137, traces of Cs 134 and 131), oxides (Eu 155, Eu 154, Eu 152), unknown residual contamination (Am 241), and plutonium peroxide (Pu 239 and associated Am 241 in an approximate 9:1 ratio). (RAP)

A summary of the cases is given in tabular form listing physical-chemical characteristics, route of entry and date, kind of operation, method of measurement-dose, and organ or part of body and treatment instituted.

<469>
Scott, L.M., and C.M. West, Union Carbide Corporation, Y-12 Plant, Oak Ridge, TN. 1968

Health Physics Application of in Vivo Gamma Spectrometry in a Uranium Processing Plant. CONF-670521; Monographs on Nuclear Medicine and Biology, No. 2; Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 543-552), 680 p.

In vivo gamma spectrometry has been used routinely for the past six and a half years in the health physics monitoring of uranium processing workers. The major problems associated with the technique are: (1) effects of surface contamination, (2) relative insensitiveness of the methods, and (3) the difficulty of predicting the base spectrum in the uranium region. The solutions to the problems at Y-12 have been to: (a) use the back detector data when contamination is indicated, (b) increase the number of detectors, and (c) derive a prediction equation and count a control population to assure continued reliability of the equation. Experience has shown that urinalysis will not point out all exposure cases and that generally once a person has been removed from uranium exposure, the urine level will return to acceptable levels long before in vivo measurements do. Consequently, it has been concluded that in vivo spectrometry is superior to urinalysis as a monitor for insoluble uranium. However, for soluble uranium and areas of low exposure potential, urinalysis is of real value. (Auth)

<470>
Valentine, A., F. Fitzgibbon, and L. Martinez, Los Alamos Scientific Laboratory, Los Alamos, NM. 1969, January 24; 1972

Health Physics at the Los Alamos "Wing 9" Hot-Cell Facility. LA-4074; CONF-690103; Part of Willis, C.A. and Handloser, J.S. (Eds.), Health Physics Operational Monitoring, Proceedings of the 3rd Health Physics Society Midyear Topical Symposium held in Los Angeles, California, January 29-31, 1969, Vol. 1. Gordon and Breach, Science Publishers, Inc., New York, New York, (p. 141-164), 1848 p.

Health Physics programs at the Los Alamos "Wing 9" hot cell facility are described. The 16-cell facility is used primarily for testing and examination of irradiated reactor fuel, but it is also the main LASL facility for materials irradiation, large source handling, and other miscellaneous hot-cell work. Eight cells are equipped with sealed alpha containment boxes for safe handling of plutonium enriched fuels. Control systems and operating practices that affect health physics at the facility are discussed as well as the health physics programs such as area monitoring, personnel dosimetry, air monitoring, surface monitoring, and monitoring instrumentation. (Auth)

<471>

WASTE DISPOSAL AND MANAGEMENT

<471>
Albensius, F.L., and W.C. Reinig, Savannah River Laboratory, Aiken, SC. 1974

Long Range Management of Transuranium-Contaminated Solid Wastes at Savannah River. DP-MS-74-26; CONF-741026; Part of Proceedings of a Symposium on the Management of Plutonium-Contaminated Solid Wastes held in Marcoule, France, October 14-16, 1974, (9 p.).

The Savannah River Plant, an 80,000 hectare USAEC production site in the southeastern United States, has generated solid wastes contaminated with 60,000 Ci of transuranium nuclides, including Pu 239, Pu 238, Cm 244, Pu 242, Am 243 and Cf 252. These wastes, along with 300,000 Ci of transuranium wastes from other AEC sites, are stored in an 80 hectare area on the plantsite. The report discusses a comprehensive planning program to retrieve and convert the wastes to noncombustible and nondispersive forms in preparation for centuries-long storage in an engineered repository. (Auth)

<472>
Anderson, K.J., Atlantic Richfield Hanford Company, Richland, WA. 1973, February

Atlantic Richfield Hanford Company. CONF-721030; Part of Proceedings of the AEC Pollution Control Symposium held in Oak Ridge, Tennessee, October 25-27, 1972, (p. 153-166), 549 p.

The Atlantic Richfield Hanford Company (ARHC) is currently installing facilities for the compaction of both contaminated and noncontaminated combustible wastes. The facilities for noncontaminated combustible wastes comprise collection containers, two front-loading compactor trucks, and a centrally-located continuous landfill. Facilities are provided for the entire Hanford site with ARCH as responsible operator. For compliance with Executive Order 11507, open-pit burning as currently practiced will be discontinued when the compaction facilities are available in early calendar year 1973. The facility for contaminated service on transuranic wastes comprises a 10-ton hydraulic press for compaction directly into 55-gallon drums for 20-year retrievable burial in compliance with Immediate Action Directive 0511-21. The compactor incorporates many features for personnel safety and contamination control. (Auth)

<473>
Blane, D.E., R.A. Schwind, H.W. Kirby, and E.L. Murphy, Mound Laboratory, Miamisburg, OH. 1974, July

New Process for Removing Plutonium from Waste Water--A Progress Report. WASH-1232; CONF-740406; Part of Proceedings of the 2nd AEC Environmental Protection Symposium held in Albuquerque, New Mexico, April 16-19, 1974, Vol. 1, (p. 321-338), 1151 p.

A process is under development at Mound Laboratory to remove radionuclides (principally plutonium 238) from process water prior to discharge of the water to the Miami River. The contaminated water normally is in the pH range from 6 to 8. Under these conditions, plutonium in all of its oxidation states is hydrolyzed and exists mostly in a colloidal or polymeric state. The level of radioactivity in the liquid stream entering the waste treatment facility averages about 25,000 dis/min/ml (11.3 uCi/l). The waste treatment process currently used has consistently reduced the radioactivity below the radioactive concentration guideline (RCG) of 11 dis/min/ml (x 10 (E-3) uCi/l). for discharge to the river. However, the process under development has the added advantage of substantially reducing the volume of solid waste generated. Pilot plant tests show that a continuous fixed bed phosphate treatment of unprocessed influent water with ferric hydroxide and polyelectrolytes is necessary to remove colloidal of polymeric plutonium before contact with the bone char. Future plans will include the following: (1) continued pilot studies with 3-valent Fe and polyelectrolytes, (2) elimination of complexed plutonium species, (3) determination of bone char capacity in plant effluent water, (4) increased sizes of bone char beds, and (5) regeneration of bone char. (Auth)

<474>
Plomeke, J.O., and W.D. Bond, Oak Ridge National Laboraotry, Oak Ridge, TN. 1974

High-level Waste Management Research and Development Program at Oak Ridge National Laboratory. CONF-740428; Part of Proceedings of the 167th National Symposium of the American Chemical Society held in Los Angeles, California, April 1-5, 1974, (14 p.).

Three areas of major interest are being emphasized: projections of future radioactive wastes from the nuclear fuel cycle for use in planning, design, and environmental assessments; investigations of the technical feasibility of removing actinide elements from wastes to render the residuals more manageable in terms of hazards and storage requirements; and evaluations of geological formations in addition to bedded salt for use in the disposal of various kinds of radioactive wastes. Projections of wastes to be generated through the year 2000 portend a future management problem of impressive size and complexity but one which can be handled within the framework of current and planned investigative programs. Early results indicate that the actinides can be removed from wastes by the minimally desired factors of 10(E+2) to 10(E+4); however, demonstrations and engineering assessments of the most promising chemical flowsheets have yet to be made. Natural salt formations are believed to offer the best prospects for disposal of high-level wastes, and the current program is directed toward obtaining confirmation of this as well as evaluating other promising geological formations for their suitability for use in the disposal of wastes. (Auth)

<475>
Davis, T.F. (Comp.), U.S. Atomic Energy Commission, Division of Technical Information, Oak Ridge, TN. 1966, July 15

Radioactive Waste Processing and Disposal, An Annotated Bibliography of Selected Literature. TID-3311 (Suppl. 2); 180 p.

Methods for processing and disposing radioactive wastes have been a continuing concern of the nuclear industry. Unclassified reports and journal literature on this subject from February 1955 through July 15, 1966 is covered in the bibliography. These selected, annotated references supplement TID-3311, TID-3311 (Suppl. 1), TID-3555, and TID-3555 (Suppl.) The

<475> CONT.
references are arranged by subject and cross referenced. Author, corporate author and report number-availability indexes are included (10,012 references.) (GBM)

<476>
Hickman, W.W., Aerojet Nuclear Company, Idaho Falls, ID. 1974, July

Plan for Retrieval of Solid Low-Level Radioactive Plutonium Waste at the National Reactor Testing Station (NRTS). WASH-1332; CONF-740406; Part of Proceedings of the 2nd Environmental Protection Symposium held in Albuquerque, New Mexico, April 16-19, 1974, Vol. 2, (p. 1007-1039), 1151 p.

A plan for retrieval of solid low-level radioactive plutonium (alpha) waste at the National Reactor Testing Station (NRTS) is discussed. The discussion deals with the descriptions, categories and volume of alpha wastes, experience gained in past alpha waste retrieval activities, the operations to be considered in the retrieval process, (for example containment of waste for transportation, waste handling, transportation of waste to its destination and backfill operations) and conceptual designs of facilities and equipment required (such as fire fighting equipment, radiation detection equipment, and general alpha contamination protection clothing and equipment for the working personnel) to retrieve alpha waste from the NRTS Burial Ground. (Auth) (PMM)

<477>
MacBeth, P.J., and W.W. Hickman, Aerojet Nuclear Company, Idaho Falls, ID. 1974, December

ITSA: Above-Ground Retrievable Storage Method for Low-Level Transuranic Wastes. CONF-740434; Part of Proceedings of a Symposium on Waste Management held in Tucson, Arizona, April 21-24, 1974, (8 p.); Nuclear Technology, 24, 383-390.

The Idaho Transuranic Storage Area (ITSA) consists of wastes packaged in fiberglass-coated wooden boxes or steel drums designed to retain their integrity for 20 years. Containers are stacked on sloped asphalt pads. The array is covered with plywood, nylon-reinforced polyvinyl sheeting, and 2 to 3 ft of earth. The need for a safe and efficient method for storage of low-level transuranic wastes prompted the development of ITSA. Storage costs in 1973 for 208,000 cubic feet of waste containing 24,600 Ci of transuranic activity average $1.04/cubic feet. (Auth)

<478>
Not given, Oak Ridge National Laboratory, Chemical Technology Division, Oak Ridge, TN. 1975, January

Program for Improved Waste Management in Commercial Nuclear Fuel Reprocessing Facilities. ORNL-TM-4783; 24 p.

The principal objective of the program proposed in the report is to decrease the long-term (more than 1000 years) hazards of radioactive wastes from commercial nuclear fuel reprocessing facilities. This is to be accomplished by modifying reprocessing methods currently in use to increase actinide recoveries and to produce waste streams that are amenable to recycle or further treatment; all wastes should be treated so as to achieve separaton into a solid, fission-product-containing fraction with low concentrations of long-lived actinides and a semipure concentrated fraction containing the actinides. After sufficient information has been accumulated from laboratory-scale studies to allow preparation of overall, detailed flowsheets and to permit making a technical evaluation, a detailed review will be made to determine if the program should be continued through construction and operation of a large-scale demonstration plant that will satisfactorily treat all waste streams from a modified nuclear fuel reprocessing facility. There is a listing and brief summary of the tasks required to carry out this program. Also included are estimates of the manpower, costs, and time required to complete the program. (Auth)

<479>
Robinson, P.A., Not given. 1974, July-August

The Leak of Tank 106-T at Hanford. Nuclear Safety, 15(4), 460-466.

This article reviews an incident in which approximately 15,000 gal of radioactive liquid waste leaked from a 533,000-gal underground storage tank at the Hanford Plant of the U.S. Atomic Energy Commission in 1973. The ensuing investigation indicated that the leaked material was retained in the soil in the vicinity of the waste tanks and posed no threat to the workers and the nearby Columbia River. However, the investigation did point out the need for improved monitoring procedures, which are presently being implemented. In 1971 a new type of tank came into use at Hanford for high-level liquid wastes that are to be stored for long periods of time. This design consists essentially of a tank within a tank. The inner steel wall provides the primary containment for the liquid. In the event of a leak, the liquid will simply flow into the annular space between the inner and outer tanks. The whole tank assembly is further contained inside a concrete vault. (PAF)

<480>
Rom, F.E., Lewis Research Center, Cleveland, OH. 1973

Summary of the Study of Disposal of Nuclear Waste Into Space. NASA-TM-X-68235; Part of Proceedings of the 10th Space Congress on Technology Today and Tomorrow, held in Cocoa Beach, Florida, April 11-13, 1973, (p. 7.19-7.26).

The National Aeronautic and Space Administration (NASA), at the request of the AEC, is conducting a preliminary study to determine the feasibility of disposing of nuclear waste material into space. The study has indicated that the Space Shuttle together with expendable and non-expendable orbital stages such as the Space Tug or Centaur can safely dispose of waste material by ejecting it from the solar system. (No launching system that is under development or planned can deposit waste material directly into the sun). The safety problems associated with all phases of launching and operation (normal, emergency and accident) of such a system are being examined. From the preliminary study it appears that solutions can be found that should make the risks acceptable when compared to the benefits to be obtained from the disposal of the nuclear waste. The techniques proposed to make such a system acceptable need to be carefully

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<480> CONT.
verified by further study and experiment. Even though more than one hundred shuttle launches would be required per year by the year 2000, the cost to the consumer would be less than five percent of his electric bill. Tests of models of waste packages impacted on reinforced concrete and soil have demonstrated the feasibility of safely containing waste material at impact speeds up to 1050 feet per second. (Auth)

<481>
Steindler, M.J., M.M. Levitz, L.E. Trevorrow, T.J. Gerding, R.J. Kullen, D.S. Webster, and L. Burris, Argonne National Laboratory, Argonne, IL. 1974, February

Chemical Engineering Division, Waste Management Programs Quarterly Report, October-December 1973. ANL-8097; 41 p.

Metal-compaction methods have been reviewed and information on the irradiation-induced property changes of Zircaloy surveyed as part of a study on the handling of fuel cladding hulls. Information originating from AEC-site visits and from a review of the open literature concerning decontamination of plutonium-contaminated materials is presented. The technical and economic feasibility of adapting reverse osmosis to the concentration of tritium from tritiated fuel reprocessing wastes was briefly evaluated. Technical feasibility was assumed from literature reports of a difference of about 3% in the self-diffusion coefficients of THO and H2O, and possibly greater differences in transport rates in solution-diffusion membranes. The costs of such a process were calculated from 1 estimates for the single-stage separation factor, 2 the heads flow rate for assumed concentrations and volumes of feed, product, and waste in an ideal cascade of membranes, and 3 published costs for reverse osmosis equipment. The result ranged from 10(E-4) to 1 mill/kWh of nuclear power, depending on the assumed single-stage separation factor and whether tritium-depleted water was recycled to the reprocessing plant. (Auth)

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Bulletin d'Information de l'Association Belge pour le Development Pacifique de l' Energie Atomique, 11(60), 13-17 63

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Part of Air Sampling Instruments for Evaluation of Atmospheric Contaminants, Fourth Edition, (p. G-1 - G-16), 558 p. 421

Part of Air Sampling Instruments for Evaluation of Atmospheric Contaminants, Fourth Edition, (p. F-1 - F-11), 558 p. 428

Part of Annual Progress Report: Scientific Works, 1972, (p. 79-80), 268 p. 368

Part of Barron, E.S.G., et al, Monthly Health Report on Problems Relating to Product for Month of May, 1945, (p. 37-47), 47 p. 101

Part of Berdjis, C.C. (Ed.), Pathology of Irradiation, Chapter 11. Williams and Wilkins Company, Baltimore, Maryland, (p. 186-212), 710 p. 103

Part of Berdjis, C.C. (Ed.), Pathology of Irradiation, Chapter 7. Williams and Wilkins Company, Baltimore, Maryland (p. 110-119), 710 p. 243

Part of Biological and Medical Research Division Annual Report, 1966, (p. 132-134), 324 p. 37

Part of Biclogical and Medical Research Division Annual Report, 1965, (p. 164-166), 338 p. 38

Part of Biclogical and Medical Research Division Annual Report, 1964, (p. 47-48), 223 p. 39

Part of Biological and Medical Research Division Annual Report, 1964, (p. 212-214), 230 p. 132

Part of Biological and Medical Research Division Annual Report, 1965, (p. 194-196), 342 p. 188

Part of Biological and Medical Research Division Semiannual Report, January through June, 1961, (p. 82-84) 189

Part of Biological and Medical Research Division Annual Report, 1965, (p. 192-193) 342 p. 191

Part of Blcom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 8. McGraw Hill Book Company, Inc., New York, New York, (p. 348-445), 808 p. 64

Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 12. McGraw Hill Book Company, Inc., New York, New York, (p. 550-597), 808 p. 93

Part of Blcom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 5. McGraw-Hill Bock Company, Inc., New York, New York, (p. 70-161), 808 p. 94

Part of Blcom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 9. McGraw Hill Book Company, Inc., New York, New York, (p. 446-501), 808 p. 159

Part of Blcom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 7. McGraw Hill Book Company, Inc., New York, New York, (p. 243-347), 808 p. 160

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Part of Blcom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 15. McGraw Hill Book Company, Inc., New York, New York, (p. 704-711), 808 p. 184

PUBLICATION DESCRIPTION INDEX

Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 11. McGraw-Hill Book Company, Inc., New York, New York, (p. 541- 549), 808 p. 185

Part of Bloom, W. (Ed.), Histopathology of Irradiation from External and Internal Sources, Chapter 4. McGraw Hill Book Company, Inc., New York, New York, (p. 32-69), 808 p. 216

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974 (p. 48-52), 384 p. 25

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 1-7), 384 p. 29

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 165-169), 384 p. 30

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974 (p. 174-178), 384 p. 31

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 136-139), 384 p. 95

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 150-155), 384 p. 96

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 170-173), 384 p. 126

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 211-214), 384 p. 139

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974 (p. 140-144), 384 p. 140

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974 (p. 37-39), 384 p. 148

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 274-276), 384 p. 157

Part of Boecker, B.B. and Rupprecht, F.C. (Eds.), Annual Report of the Inhalation Toxicology Research Institute, October 1, 1973 through September 30, 1974, (p. 29-36), 384 p. 217

Part of Bourne, G.H. (Ed.), The Biochemistry and Physiology of Bone, Chapter 23. Academic Press, Inc., New York, New York, (p. 729-765), 875 p. 390

Part of Cherdyntsev, V.V., Uranium 234, Chapter 7. Keter Press, Jerusalem, Israel, (p. 177-234), 234 p. 301

Part of Crook, M.A. (Ed.), Proceedings of a Symposium on Liquid Scintillation Counting held in Brighton, United Kingdom, September 13-16, 1971. Heydens and Son, Ltd., London, England, (p. 155-165) 408

Part of Davis, J.J. (Ed.), Hanford Biology Research Annual Report for 1958, (p. 54-60), 156 p. 53

Part of Davis, J.J. (Ed.), Hanford Biology Research Annual Report for 1958, (p. 106-108), 156 p. 252

Part of Division of Biological and Medical Research Annual Report, 1972, (p. 121-125), 236 p. 131

Part of Dougherty, T.F., Research in RAdiobiology, Annual Report of Progress in the Internal Irradiation Program, (p. 188-198), 222 p. 5

Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 62-72), 136 p. 32

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Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 97-125), 268 p. 105

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Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 126-143), 268 p. 115

Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 76-83), 136 p. 137

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Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 164-172), 268 p. 230

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Part of Dougherty, T.F., Research in Radiobiology, Semiannual Report of Work in Progress in the Internal Irradiation Program, (p. 71-75), 144 p. 244

Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress in the Internal Irradiation Program, (p. 70-84), 326 p. 246

Part of Dougherty, T.F., Research in Radiobiology, Semiannual Report of Work in Progress on the Chronic Toxicity Program, (p. 32-37), 104 p. 247

Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 43-47), 136 p. 248

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Part of Dougherty, T.F., Research in Radiobiology, Annual Report of Work in Progress on the Chronic Toxicity Program, (p. 109-121), 136 p. 249

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Part of Dougherty, T.F., Research in Radiobiology, Semiannual Report of Work in Progress in the Internal Irradiation Program, (P 76-95), 144 p. 294

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Part of Enewetak Radiological Survey, (p. 225-348), 736 p. 315

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Part of Feige, Y. (Ed.), Proceedings of the Regional Symposium on Radiation Protection held in Jerusalem, Israel, March 5-8, 1973 (p. 805-819) 404

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Part of Gus'kova, K. and Baysogolov, G.D., Radiation Sickness in Man, (p. 25-38), 560 p. 353

Part of Haghiri, F., AEC Final Technical Report for March 1971 to August 1972, (p. 58-66), 67 p. 296

Part of Hardy, E.P., Jr., Fallout Program Quarterly Summary Report, June 1, 1974 through September 1, 1974, (p. I-2 - I-10), 169 p. 306

Part of Hardy, E.P., Jr., Fallout Program Quarterly Summary Report, December 1, 1967 through March 1, 1970, (p. I-9 - I-13), 144 p. 417

Part of Health Physics Division Annual Progress Report for Period Ending July 31, 1965, (p. 212-213), 257 p. 22

Part of Hodge, H.C., et al (Eds.), Uranium, Plutonium, Transplutonic Elements, Chapter 14. Springer-Verlag, New York, New York, (p. 613-667), 995 p. 466

Part of Jacobson, L.O., et al, Report of Health Activities for Month of November, 1945, (p. 3-7), 7 p. 57

Part of Koelzer, W. (Comp.), Proceedings of the 6th Annual Scientific Symposium of the Association for Radiation Protection held in Karlsruhe, Germany, May 17-19, 1972, (p. 253-257), 361 p. 374

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 419-423), 680 p. 82

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 56-64), 680 p. 129

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 73-80), 680 p. 192

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 403-412), 680 p. 194

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 81-90), 680 p. 199

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 273-290), 680 p. 268

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 3-18), 680 p. 303

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 471-481), 680 p. 317

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 482-486), 680 p. 319

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 164-170), 680 p. 337

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (P. 189-207), 680 p. 339

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 427-434), 680 p. 370

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 587-592), 680 p. 375

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 593-599), 680 p. 394

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 266-278), 680 p. 423

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 171-188), 680 p. 430

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 209-221), 680 p. 432

PUBLICATION DESCRIPTION INDEX

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 256-265), 680 p. 465

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited RAdionuclides held in Richland, Washington, May 15-17, 1967, (p. 435-450), 680 p. 468

Part of Kornberg, H.A. and Norwood, W.D. (Eds.), Proceedings of a Symposium on the Diagnosis and Treatment of Deposited Radionuclides held in Richland, Washington, May 15-17, 1967, (p. 543-552), 680 p. 469

Part of Kornberg, H.A. and Swezea, E.G. (Eds.), Hanford Biology Research Annual Report for 1961, (p. 41-43), 180 p. 14

Part of Kornberg, H.A. and Swezea, E.G. (Eds.), Hanford Biology Research Annual Report for 1961, (p. 50-51), 180 p. 46

Part of Kornberg, H.A. and Swezea, E.G. (Eds.), Hanford Biology Research Annual Report for 1963, (p. 42-43), 259 p. 52

Part of Kornberg, H.A. and Swezea, E.G. (Eds.), Hanford Biology Research Annual Report for 1961, (p. 44-49), 180 p. 146

Part of Kornberg, H.A. and Swezea, E.G. (Eds.), Hanford Biology Research Annual Report for 1961, (p. 36-40), 180 p. 147

Part of Kornberg, H.A., et al, Biology Research Annual Report, 1955, (p. 61-72), 188 p. 264

Part of Kornberg, H.A., Hanford Biology Research Annual Report for 1959, (p. 116-121), 208 p. 12

Part of Kornberg, H.A., Hanford Biology Research Annual Report for 1959, (p. 72-73), 208 p. 174

Part of Kornberg, H.A., Hanford Biology Research Annual Report for 1959, (p. 122-128), 208 p. 267

Part of Kornberg, H.A., Hanford Biology Research Annual Report for 1957, (p. 167-171), 226 p. 433

Part of Lebedinskii, A.V. and Moskalev, Yu.I. (Eds.), Biological Effects of Radiation and Problems of Radioactive Isotope Distribution, Translated from a publication of the State Publishing House of Literature in the Field of Atomic Science and Technology, Moscow, USSR, (p. 32-42), 187 p. 26

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Part of Manual on Radiation Haematology, Chapter 21, (p. 215-242) 389

Part of McClellan, R.O. and Rupprecht, F.C. (Eds.), Inhalation Toxicology Research Institute Annual Report, October 1, 1973 through September 30, 1974, (p. 269-273), 342 p. 156

Part of Moghissi, A.A. and Carter, M.W. (Eds.), Proceedings of a Symposium on Tritium held in Las Vegas, Nevada, August 30-September 2, 1971. Messenger Graphics, Publishers, Las Vegas, Nevada, (p. 240-244), 807 p. 155

Part of Moghissi, A.A. and Carter, M.W. (Eds.), Proceedings of a Symposium on Tritium held in Las Vegas, Nevada, August 30-September 2, 1971. Messenger Graphics, Publishers, Las Vegas, Nevada, (p. 430-455), 807 p. 309

Part of Moghissi, A.A. and Carter, M.W. (Eds.), Proceedings of a Symposium on Tritium held in Las Vegas, Nevada, August 30-September 2, 1971. Messenger Graphics, Publishers, Las Vegas, Nevada, (p. 639-646), 807 p. 401

Part of Monthly Health Report on Problems Relating to Product for Month of May, 1945, (p. 12-15), 45 p. 1

Part of Monthly Health Report on Problems Relating to Product for Month of May, 1945, (p. 5-11), 45 p. 16

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Part of Moskalev, Yu.I. and Kalistratova, V.S. (Eds.), Biological Effects of Radiation from External and Internal Sources, (p. 427-434), 515 p. 272

Part of Nickson, J.J., Health Information Meeting held January 16, 1945, (p. 3-6), 6 p. 179

Part of Proceedings of a Symposium on Research Animals in Medicine held in Washington, D.C., January 28-30, 1972, (14 p.) 109

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Part of Proceedings of the Joint Meeting of the American Nuclear Society and the Atomic Industrial Forum and Nuclear Energy Exhibition held in San Francisco, California, November 11-15, 1973. Published in Transactions of the American Nuclear Society, 17, 541-542 415

Part of Proceedings of the Plutonium Information Symposium held in Los Alamos, New Mexico, January 4-5, 1974, (p. 2-7), 96 p. 288

Part of Proceedings of the Rocky Flats Symposium on Safety in Plutonium Handling Facilities held in Golden, Colorado, April 13-16, 1971, (p. 56-67), 457 p. 438

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Part of Proceedings of the 12th Annual Symposium of the Radiation Research Society held in Miami, Florida, May 18-20, 1964. Published in Radiation Research, 22(1), 222 170

Part of Proceedings of the 13th AEC Air Cleaning Symposium held in San Francisco, California, August 12-15, 1974, (10 p.) 410

Part of Proceedings of the 13th AEC Air Cleaning Symposium held in San Francisco, California, August 12-15, 1974, (13 p.) 444

Part of Proceedings of the 14th Annual Symposium of the Radiation Research Society held in Coronado, California, February 13-16, 1966. Published in Radiation Research, 27, 549 76, 224

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Part of Proceedings of the 21st Annual Symposium of the Radiation Research Society held in St. Louis, Missouri, April 29-May 3, 1973. Published in Radiation Research, 55(3), 516 17

Part of Proceedings of the 21st Annual Symposium of the Radiation Research Society held in St. Louis, Missouri, April 29-May 3, 1973. Published in Radiation Research, 55(3), 515 65

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