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AEC
RESEARCH
and
DEVELOPMENT
REPORT

**PACIFIC NORTHWEST LABORATORY
MONTHLY ACTIVITIES REPORT
FOR FEBRUARY 1967**

**DIVISION
OF
BIOLOGY AND MEDICINE
PROGRAMS**

MARCH, 1967

BATTELLE-NORTHWEST

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PACIFIC NORTHWEST LABORATORY

RICHLAND, WASHINGTON

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PACIFIC NORTHWEST LABORATORY

MONTHLY ACTIVITIES REPORT

FEBRUARY 1967

AEC DIVISION OF BIOLOGY AND MEDICINE PROGRAMS - R. S. PAUL

RADIATION EFFECTS - GENERAL

Mechanism and Treatment of Gastrointestinal Radiation
Effects - M. F. Sullivan

In previous experiments we have studied the effect of bile on movement of sodium and tritiated water between blood and the lumen of the in situ perfused rat small intestine. In using similar techniques, we found that movement of water and sodium in both directions was sharply depressed by prior irradiation, and that diversion of bile flow from the intestine did not alter this effect in a manner which could explain the efficacy of bile diversion in preventing the diarrhea normally associated with the intestinal radiation syndrome. We have measured the movement of water and sodium into and out of a tied-off segment of the intestine which was not perfused with isotonic buffer. Results indicated that both sodium and water movement into the intestine is increased after radiation, and movement of both out of the intestine is decreased. Bile diversion, to a large extent, reversed the effects of irradiation. The results obtained by this isolated loop technique, which employs the contents normally present in the intestine and not a perfused artificial medium, are in complete accord with the events that are visible as symptoms of radiation injury and with the effects of bile diversion on these symptoms. The previously employed perfusion technique, while widely accepted as physiologic for studying normal intestinal function, may be totally inappropriate for studying function in an abnormal organ that no doubt has an intestinal content that is also abnormal.

Studies in progress indicate that active chloride transport does not occur in the rat large intestine although it was demonstrated in the small bowel. Bile was shown to affect the bioelectric transport process in the intestine, which could explain its influence on the movement of substances like sodium and glucose that are absorbed by an electrogenic process. An experiment is in progress to study the effect of the pancreatic secretion in the irradiated gut.

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Bile fistula rats that were held for intervals up to 59 days after cannulation exhibited mucosal cellularity that was indistinguishable from control sections at the later times. The major response of goblet cell proliferation was seen at 5-7 days. When the mucopolysaccharides of cannulated rats were labeled with sulfur-35 and rectal excretion of ^{35}S mucus was measured radiometrically, no consistent influence of bile was seen.

From electron microscopic studies, we have some preliminary evidence which indicates that the radiation-induced enteric coat on the microvilli of intestinal epithelia cells is elaborated as early as 5 hours postirradiation. At this time interval, we find numerous cytoplasmic vesicles that stain intensely with colloidal thorium at a low pH. This finding is at least consistent with the notion that the acid mucopolysaccharide portion of the enteric surface coat is synthesized inside the cell and is then transported to the surface coat by the vesicles.

Late Effects of Radiating Skin - J. L. Palotay

A Palouse pig exposed on either side of the lateral thoracic region to about 10,000 rads of 2 MeV electrons from the Van de Graaff accelerator in 1956 was killed after development of a posterior paralysis. The exposed sites had not changed in gross appearance in the past two years and consisted of a large depressed scar about 5 x 12 cm and about 3 cm deep. There were numerous endometrial cysts and a uterine tumor present. Histo-pathologic studies have not been completed.

TOXICITY OF RADIOELEMENTS

Factors Affecting the Toxicity and Metabolism of Radionuclides - M. F. Sullivan

A study on the effect of pregnancy and age on plutonium distribution and toxicity in the rat is in progress. Both colloidal and ionic ^{239}Pu were injected into various age groups that will be killed at intervals to follow changes in distribution with time.

Factors Affecting the Toxicity and Metabolism of Radionuclides in Aquatic Organisms - R. E. Nakatani

The distribution of glycogen in Columbia River freshwater mussels was studied in preparation for planned investigations of radiation effects. Glycogen serves as an important index of

of the general health of these animals. Glycogen was found deposited very heavily throughout the Leydig (connective tissue) cells and the outer mantle epithelium. Lesser glycogen deposits were observed in most other tissues. The epithelium of the digestive gland and the inner mantle epithelium were found to be strongly PAS positive, but they contained only a very small amount of glycogen. The kidney epithelium possesses two distinct types of cells, both of which are highly PAS positive. One type contains mainly glycogen, while the other type contains an unknown mucopolysaccharide.

Effects of Radiostrontium in Miniature Swine
- W. J. Clarke

An additional osteosarcoma was found in the ulna of a pig born to a 625 μCi level sow. This animal, besides uterine exposure, had received 156 μCi of ^{90}Sr from weaning at 6 weeks until 11 weeks of age. No further radioisotope was fed this pig up to the time of death at 4½ years of age. A large, destructive giant cell tumor of the mandible was diagnosed in a pig that died at approximately 4 years post intravenous injection of a single dose of 1870 μCi ^{90}Sr . Of particular interest this month was the diagnosis of a Hodgkins-like disease in a 734-day-old F_1 pig that had been on 125 μCi ^{90}Sr /day. This neoplastic process is considered by some to be a particular variant of malignant lymphoma.

An additional group of miniature swine was started on a short term integrated study of the biological effects of daily ingestion of 625 μCi ^{90}Sr . Hematopoietic cell generation times are being investigated in these animals following tritiated thymidine injections. In addition, ^{90}Sr induced chromosomal aberrations and new biochemical parameters of damage are being studied.

Porcine kidney and testicle tissue cultures have been maintained through the 9th and 3rd passage, respectively. Samples of kidney fibroblast cultures were inoculated at 3rd, 5th and 7th passage with cell-free filtrate (250 millimicron) of spleen homogenate, serum, and plasma composite from three ^{90}Sr induced porcine leukemias. Grossly, there appears to be an enhanced growth rate of the cells, which may be due to the added nutritive value of the filtrate. In the inoculated cell cultures there appears to be a tendency for formation of abnormal cells which are large, have abundant cytoplasm and

contain from 2-5 nuclei. Pellets and scrapings of these inoculated and control cells have been submitted for electron microscopic study.

Inhalation Studies - W. J. Bair

Of 12 dogs exposed to $^{239}\text{Pu}(\text{NO}_3)_4$, 8 were sacrificed when death was imminent and another (No. 388) was sacrificed for tissue distribution data. Tissue distribution data for 5 dogs are given in the table below. The highest concentration of ^{239}Pu occurred in the tracheobronchial lymph nodes followed in decreasing order by lungs, mediastinal lymph nodes, nasal turbinates, liver, skeleton and other lymph nodes.

Body Burden and Pu Distribution After Inhalation of $^{239}\text{Pu}(\text{NO}_3)_4$

Dog No.	Postexposure	Body Burden μCi	% of Body Burden			
			Lung	Skeleton	Liver	Tracheobronchial & Mediastinal Lymph Nodes
424	75	47	60	25	10	2
420	88	48	60	25	10	3
388	95	6	64	17	15	2
396	102	65	51	33	9	4
458	109	19	54	31	10	2

Maximal phagocytosis, after intraperitoneal injection of $2\mu\text{Ci } ^{239}\text{PuO}_2$ particles, occurred within one or four hours as determined by visual count or autoradiography, respectively. At four hours, analysis by autoradiography indicated twice the phagocytosis indicated by visual count. Particle size in relation to visual acuity and statistical probability for contact between particle and cell probably accounted for this difference. Over 80% of the particles had been phagocytised during the first four hours. Macrophages were the most efficient phagocytes. There was no change in the ^{239}Pu activity of the peritoneal wash during the first five hours. The activity decreased to negligible levels at 24 hours. Less than 0.2% of the administered dose was excreted via urine and feces during the first 48 hours. Some cytological damage was observed as the result of $^{239}\text{PuO}_2$ phagocytosis, including cytoplasmic vacuolization

(Giemsa stain) and dissolution of nuclear material (Feulgen's stain) around some particles. Intraperitoneal calcium administration resulted in the formation of agglutinated masses of cells. Nearly all of the $^{239}\text{PuO}_2$ particles were associated with these clumps of cells.

Uranium Ore Inhalation - Radiochemical Studies - R. W. Perkins

Measurements for ^{210}Pb and ^{210}Po in bioassay samples from Alaskan Eskimos for the months of March, April, May, September and October, 1966, showed relatively little variation in the ^{210}Pb with time. However, the average ^{210}Po decreased to about a third during this period. The reason for this drop is not clear but appears to be associated with food collection practices of the Eskimos. Samples collected in the spring may serve as a source of food through the summer months during which time the ^{210}Po (138 d) in the caribou meat would decay significantly while the ^{210}Pb would remain essentially constant. Lichen samples collected from the Olympic Peninsula during late 1966 contained ^{210}Po concentrations of 1.3 nCi/kg, which are much lower than those of the Alaskan lichen. Moss samples from the Peninsula showed a comparable ^{210}Po concentration to that in the Alaskan lichens.

Excretion Rates vs. Lung Burdens in Man
- C. E. Newton, Jr./W. J. Bair

Further calculations were made continuing the development of experimental design based on present knowledge of plutonium in the body. Parts of a model for predicting urinary excretion of plutonium resulting from inhaled plutonium oxide or nitrate based on the new ICRP lung model were programmed for computation.

Space Nuclear Systems Studies - R. C. Thompson

It has not been clear whether the effects of $^{238}\text{PuO}_2$ particles on leaf surfaces were due to alpha radiation or to thermal heat from the particles. A temperature sensitive paper, Thermotap, turns from white to black in zones where the specific indicator temperature has been exceeded. When 220°F test paper with a $200\ \mu$ $^{238}\text{PuO}_2$ particle on it was placed in a hood with a rapid flow of air, a well-defined black spot was formed. No change was observed after 2 days exposure of paper sensitive to 440°F . A slight change was noted on paper sensitive to 400°F .

From this it would appear that damaging temperatures are generated in the particles and the energy effectively transferred to a supporting surface. Under conditions of relatively quiet air, appreciably higher effective temperatures might be expected.

A total of twenty-three 120μ $^{238}\text{PuO}_2$ particles was given to 7 dogs by intratracheal intubation. All particles were cleared by 11 days. Twenty 50μ particles were deposited in the lungs of 6 dogs. Only 3 dogs retained particles after one week. Two previously intubated dogs have retained single 120μ particles for 6 months and 2 for over one month.

TOXICITY OF RADIOELEMENTS

Biological Systems Model Development - R. D. Benham

Work continued on the simulation which will describe the movement of ^{65}Zn in the limpet snail. Initial simulations of the limpet weight cycle, ^{65}Zn concentration in the river water, limpet lifetime cycles, and the biological half-life of ^{65}Zn in the limpet were developed.

The river flow is generated by a function generator which has been set from an average annual river flow curve. Presently it is assumed that reactor output of ^{65}Zn is constant, but initial simulation of the ^{65}Zn concentration in river water indicates that the variation in normal Zn concentration in the river water must be included in the computation of the amount of ^{65}Zn produced by the reactors. Since the lifetime of the limpet is approximately 13 months and the reproduction cycle is 12 months, it is necessary to duplicate the computation of every quantity except river flow, river temperature, ^{65}Zn concentration in the algae, and ^{65}Zn concentration in the water.

The wide variation of biological elimination rates for body compartments was reported last month and several methods for handling the problem were formulated. These were:

1. Change time scales in the middle of the solution by:
 - a. Changing coefficients manually,
 - b. Using relays, with previously set coefficients, to switch from one time scale to another quickly,
 - c. Hybridizing the model and letting the digital computer do the rescaling and set the new coefficients automatically.

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BNWL-403

2. Using dimensionless time scaling.

Converting the analog simulation to a hybrid simulation will be done over a long period of time (as the hybrid system becomes operational and as knowledge of how it works increases). Dimensionless time scaling does not yield the results hoped for and this method has been discarded. Since using relays is much faster than setting pots in the middle of the run, this method is to be used. Where needed, two potentiometers, in parallel, are selected by a set of relay contacts. The potentiometers each have different time scales associated with their settings, a slow time scale and a fast time scale. Halfway through a run the computer is returned to the initial conditions, the relays are energized, and the computer finishes the run. The results of runs using this method have been compared with biology data, and the model's pathways from the lungs to the blood and subsequently to the bone, liver, and kidneys seem to match the data quite well.

COMBATING DETRIMENTAL EFFECTS OF RADIATION

Removal of Internal Emitters - J. L. Palotay

A Hanford Miniature female pig injected intradermally five years ago with ^{239}Pu nitrate was killed because of prolonged intractable anorexia. A total of 111 sites had been injected at levels of 0.0016, 0.008, 0.04, 0.02, 1.0 and 5.0 $\mu\text{Ci}/\text{site}$. Total Pu^{239} injected was about 94 μCi . The skin lesions consisted of small depressed areas, usually dose-related. There was no gross evidence of tumor formation in any of these areas. Of particular interest were the hepatic lesions. The liver was cirrhotic, interlobular tissue was increased, and throughout the parenchyma were scattered foci of what appeared to be neoplastic tissue, 1 mm to 4 cm in diameter. This may be a case of liver neoplasia, but final diagnosis must await the completion of histologic examinations.

Removal of ^{90}Sr via saliva was studied in two pygmy goats which had been fed 125 μCi $^{90}\text{Sr}/\text{day}$ for a year. The goats were anesthetized with Surital and given 20 cc Rumene intraruminally. Over 60 g of saliva was collected in 30 minutes from one goat; vomitus interfered with the total collection from the second goat. Calcium and ^{90}Sr were measured in serum and saliva:

	<u>nCi ⁹⁰Sr/g</u> <u>of serum</u>	<u>nCi ⁹⁰Sr/g</u> <u>of saliva</u>	<u>(⁹⁰Sr/Ca) saliva</u> <u>(⁹⁰Sr/Ca) serum</u>
Goat 14	2.2	0.41	3.1
Goat 25	1.3	4.8	14.7

These results are similar to those obtained by Setala with rodents and cats. Collection of saliva from swine has not been successful to date.

Rats injected with $^{239}\text{Pu}(\text{NO}_3)_4$ and treated with lipoic acid did not excrete plutonium at any different rate than controls, even if given NH_4Cl or Na lactate orally as an additional agent. The Na lactate and NH_4Cl did reduce the lipoic acid toxicity, however. The only effect of lipoic acid was to increase the relative quantity of plutonium deposited in the liver.

MOLECULAR AND CELLULAR LEVEL STUDIES

Cellular Regulatory Mechanisms - W. H. Matchett

The hunt for kynureninaseless mutants of Neurospora crassa continued. About 75 independently isolated strains exhibit a requirement for tryptophan and niacin, but are unable to convert tryptophan to anthranilic acid. Presumably, some of these mutants will be lacking in the ability to convert kynurenine to anthranilic acid and, therefore, will be the desired kynureninaseless mutants. In the near future we expect to examine these strains enzymically for kynureninase activity.

Characterization of Radiation-Induced Free Radical Reactions in Aqueous Systems - D. R. Kalkwarf

While a number of organic radicals have been detected by ESR measurements in the present irradiated-flow system, it is likely that others react so rapidly that their spectra cannot be observed directly. It is suspected that these include the products of reactions between hydroxyl radicals and amino acids, alcohols and sugars, radicals which could play an important role in promoting radiobiological damage. In order to obtain evidence for their existence and chemical behavior, a technique initiated last month was developed further. This technique compares the abilities of organic radicals to chemically reduce

p-nitrobenzoate ion by one-electron transfer, a process readily detected due to the stability and characteristic ESR spectrum of the p-nitrobenzoate radical-anion. Various compounds were added to a solution of p-nitrobenzoate saturated with nitrous oxide in the irradiated flow system and a search was made for the 27-line ESR spectrum of the p-nitrobenzoate radical-anion. Since nitrous oxide was present in sufficient concentration to convert all hydrated electrons to hydroxyl radicals, the p-nitrobenzoate radical-anion could only arise by electron transfer from a radical derived from the additive. Addition of either methanol or ethanol produced this electron transfer, indicating that they formed radicals, following hydroxyl-radical attack, which undergo electron transfer more rapidly than competing processes. No p-nitrobenzoate radical-anion was formed upon addition of either valine or tyrosine suggesting that if radicals are formed from these amino acids by hydroxyl-radical attack, they undergo reactions which are more rapid than electron transfer.

Another step in the study of the more-transient radiation-induced radicals was completed with modification of the Van de Graaff electron accelerator to millisecond-pulsing operation. Introductory experiments included observation of the optical absorption spectra of the ozonide radical-anion and a transient in the radiolysis of FD&C Blue No. 1, the efficient hydroxyl-radical scavenger. From the absorbence of the ozonide radical-ion at 430 mμ, the absorbed dose per millisecond pulse was calculated to be 1500 rads.

ENVIRONMENTAL RADIATION STUDIES

Terrestrial Ecology - R. E. Nakatani

Field trapping of small mammals was started at the Rattlesnake Springs study site. The high success in trap and recapture attempts was encouraging. Future plans call for radiation and return of the animals to the field to evaluate the effect of radiation on field living populations.

Plant Uptake of Radionuclides - F. P. Hungate

It has been reported that Bromus tectorum (cheatgrass) requires a seed vernalization to maintain its normal growth and

reproduction cycle. The absence of a cold period on the Hanford reservation between the seed production stage in late Spring and Autumn germination is evidence against such a postulate. If a vernalization period is necessary, it is more logical to assume that the seedling is responsive to cold periods.

Both seed and seedling vernalization are being tested under laboratory conditions. In an initial test of seedling vernalization, seedlings (20 days from seed) were given 0, 1, 2, 3, 4, and 5 nycto-periods at a low temperature ($\sim 3^{\circ}\text{C}$) and returned daily to standard growing conditions. Soil moisture was maintained by daily irrigations to near field capacity. The flowering expression was weak and not considered to be significant. It was not possible to relate the time or degree of flowering to the absence or length of cold treatment. The length of the seedling vernalization period may have been too short; evaluation of this period is in progress.

Generating $^{131}\text{I}_2$ at a constant rate over periods up to an hour has been difficult, and for longer periods, nearly impossible. Silicone rubber, used to seal equipment to plant leaves, was observed to sorb large quantities of iodine and subsequently to release the gas. The possibility of using the silicone rubber as an iodine generator was tested using 114 g of rubber strips initially charged with 200 μCi ^{131}I . With an air flow through the rubber of 944cc/min, the release rate was initially 300 pCi/liter of air increasing to 700-900 pCi/liter during the second to fifth days, and falling to 500 pCi/liter at the end of 8 days. The relatively uniform rate of iodine release from this material and the possibility that the impregnated rubber could be stored under sealed conditions when not in use make it well suited as a source for gaseous ^{131}I exposures.

Columbia River Ecology - R. E. Nakatani

Concentrations of ^{51}Cr , ^{59}Fe , and ^{65}Zn increased in net plankton and caddis larvae over previous month's levels, but other samples showed little change.

Three ^{65}Zn uptake runs performed on mature (4 months old) periphyton communities in the enlarged, closed system produced the most reproducible results to date. With an initial ambient concentration of 3 nCi/ml, runs of from 11 to 17 hours resulted in total uptakes of from 2.0 to 2.6 nCi, and concentrations in the periphyton of from 0.22 to 0.026 nCi/mg dry weight.

Eskimo Food Chain Studies - R. E. Nakatani

The fourth field trip to Alaska, which includes whole-body counting of Alaskan natives at Anaktuvuk Pass, Arctic Village and Ambler, is in progress. Sampling of lichens and caribou on the winter ranges is being emphasized.

Earth Sciences - W. A. Haney

Examination of numerous landslides indicates apparent similarities between many of them. Those features include geologic environment, altitudes of slides, apparent age, and a tendency toward concentration in the Pasco Basin. Many thus appear to have a common cause and may have been formed by a common event.

Between 10,000 and 33,000 years ago, glacial Lake Missoula drained in a flood or floods of catastrophic magnitude that temporarily inundated the Pasco Basin to altitudes up to 1200 feet above sea level. Rock in the anticlinal ridges was saturated to that altitude. Rapid draining of the lake caused outflow of those waters. Where drainage was impeded by steeply dipping, clay-rich interbeds, hydrostatic heads combined with wetting of the clays to probably induce many slides throughout the basin.

Rapid loading and unloading of the earth's crust by the flood waters probably also induced many, very shallow-seated earthquakes that may have helped trigger the slides. Some slides lie where large volumes of water impinged against the ridges. The Corfu slide lies at the point where flood waters from the Drumheller Channels were forced to turn westward down Crab Creek or southeastward into the Othello Channels. Oversteepening of the slopes by erosion could well have contributed to causing that slide.

Landslides in the Pasco Basin do not necessarily reflect major earthquake activity at least within the last 10,000 years.

The use of blending methods to enable piece-wise fitting of potential data to assure continued partial derivatives was found to be limited to rectangular regions with identical scaling. This subtle requirement in the MIT-developed methods has required additional investigation and may require the development of an entire additional class of functions. Such functions

will likely be similar in form to the slope-correcting operation proposed in the blending document. If such functions can be obtained, then the utilization of the blending methods will be considerably enhanced for this application in the analysis of ground water data.

ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Radioisotopes as Particles and Volatiles - L. C. Schwendiman

The theoretical density of uranine was determined to be $1.53 \pm 0.01 \text{ g/cm}^3$, a value in good agreement with reported values. The densities of 3.5μ and 27.5μ monodisperse particles prepared with a spinning disc generator were found to be 1.25 and 1.2, respectively, values somewhat lower than the measurements of the intermediate size particles reported earlier.

Performance characteristics of the high speed spinning disc aerosol generator were measured at disc speeds of 55,000, 68,000 and 80,000 rpm. Measured particle size distributions were narrow with standard deviations ranging from 3 to 11% of the mean. Control of particle sphericity required addition of water or butanol to the ethanol-dye solution. Butanol proved to be very effective for this purpose. Particle concentrations up to 1500 particles per cm^3 were generated without serious agglomeration occurring. This concentration is an order of magnitude higher than can be obtained with the former generator. Particles as small as 0.5μ were generated at 80,000 rpm, providing encouragement that the goal size of 0.3μ can be obtained.

Radioactive Fallout Rates and Mechanisms - R. W. Perkins

Measurements of ground level air concentrations of fallout radionuclides at Richland, Washington since the cessation of the major atmospheric testing at the end of 1962 has shown a "mean atmospheric residence time" for stratospheric debris of 11.7 months. This value can be compared to 10 months obtained by the Stardust sampling program in which direct sampling of stratospheric air was performed. This very close agreement points to the value of ground base measurements in defining stratospheric residence time of nuclear weapons testing debris. On comparing air concentrations at Point Barrow, Alaska, with that at Richland, Washington, over the past two years, it was observed

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that the maximum air concentrations occurred two months earlier at the northern latitude. Two measurements of the cosmic ray produced radionuclides in rain from a single storm showed a much higher ratio of the short-lived radionuclides relative to ^{24}Na (15 hr) in the rain sample taken at the end of the storm than in the sample taken earlier in the storm. This provides direct evidence that the time spent in droplet formation in the cloud was much less toward the end of the storm than early in the storm. It is planned to use a mobile counting laboratory and to make several consecutive measurements of cosmic ray produced radionuclides from single storms moving in over the Olympic Peninsula. This can provide the much needed basic information on precipitation scavenging of airborne radionuclides. The cosmic ray produced radionuclide ^{24}Na has been measured for the first time in air near sea level. This measurement, made on the Olympic Peninsula during a period of a rather high rainfall, showed an apparent production rate of 6×10^{-10} ^{24}Na nuclei per gram of air per second. This value agrees well with Lal's calculated value of 5×10^{-10} nuclei per gram of air per second, but when this production rate is extrapolated to 9,000 feet where we also have a ^{24}Na measurement it is a factor of 4 low. Our planned high altitude sampling flights will permit direct measurements of the production rate of ^{24}Na as a function of altitude and at altitudes where equilibrium is certain and should, therefore, provide absolute production rate figures. A computer program using the Rudstam equation has been written to calculate the relative production rates from atmospheric argon of cosmic ray produced radionuclides. These calculated production rates will be compared with absolute productions measured in the high altitude sampling program. Some 40 activation analyses were performed on snow samples in which silver salts and bromine gas were released to measure precipitation scavenging coefficients. This is a joint program with the Fallout Research Unit.

^{55}Fe in the Human Population of the World - R. W. Perkins

Measurements of the ^{55}Fe in the blood samples of cattle, caribou and man have been made in a continuing program to determine the annual variations. Based on a 1,000 lb beef animal, the body burdens of ^{55}Fe were 441, 228 and 108 nCi, respectively, for the months of December 1964, 1965 and 1966. Similar measurements of caribou blood from Anaktuvuk Pass, Alaska, indicated body burdens of 744, 953 and 725 nCi, respectively, for January 1965, 1966 and 1967. The higher concentrations in the Alaskan

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animals during the last two years were probably related to the fact that they are somewhat older animals and therefore have had a longer period to accumulate the iron, and also to the fact that their main food supply, lichen, retains the ^{55}Fe for longer periods of time than fodder from this area. Blood samples from people, 100 males and 25 females, collected at the December 1966 blood drawing at Richland, Washington, showed body burdens of 24 and 22 nCi, respectively. Year end body burdens for 1964, 1965 and 1966 for males were 9.0, 21 and 24 which indicate a leveling-off of body burdens. Previous studies have shown that iron can be measured in small samples of human hair. Two hundred samples of hair from local barber shops have been collected for ^{55}Fe analysis and the concentrations in the hair will be compared with those observed in the blood samples to provide a factor for estimating ^{55}Fe burdens based on hair sample analysis.

Fallout Phenomenology - R. J. Engelmann

A previously developed computer program for determining Montgomery stream functions required that data be reduced from pressure to log pressure. Mixing ratios were computed from a graph. Both of these data reductions required vital time needed for analysis. Therefore, an interface computer program was developed which takes the logarithm of pressure and computes the mixing ratio. Also, it sorts temperature and wind data according to increasing values of pressure and height. This greatly simplifies the data input format, allowing the direct use of teletype or NHDT radiosonde data by personnel with a minimum of training. Either dew point or relative humidity can be used in the appropriate deck of the computer program. It is possible to process data placed on Fortran coding forms by persons off-site with no effort.

Transport and Diffusion - C. E. Elderkin

A real time tracer sampler moving crosswind through a tracer plume was used to investigate relationships between mean and instantaneous tracer concentrations. To date only three field experiments involving this technique have been carried out. Although this is not a sufficient number of tests from which to draw many firm conclusions, the tests give enough data from which to attempt various approaches which might be used to investigate long term vs. instantaneous plume concentrations.

A comparison of the frequency of instantaneous crosswind integrated concentrations which are greater than the 30-minute mean crosswind integrated concentration with those that are less, reveals that about 2/3 of the values fall in the below-the-mean group.

The mean crosswind distribution of tracer concentration as measured on a series of stationary filters was compared to the same distribution as computed from "instantaneous" distributions obtained from the moving sampler. On the test in which the most crosswind traverses were made (nine), the integrated crosswind areas are within 10% of each other and the distributions are quite similar in character.

Data are tabled which present the frequency of instantaneous values of concentration as compared to the peak mean crosswind concentration for a 30-minute period.

Comparisons were made of one minute averages of wind direction and locations of instantaneous plume intercepts for one test where considerable meander made this possible. The one minute average directions were found to persist quite well for travel to 800 meters from the source, showing up quite well in the meander of the plume. Travel time to the point of sampling led to an estimate of effective transport height near 6 meters, the logarithmic mean of the 26 meter release and 1.5 meter sampling heights. A relationship was indicated between the standard deviations of wind direction about the one minute averages and the instantaneous plume widths for the individual intercepts. These preliminary results offer confidence that eventually that portion of the turbulence spectrum responsible for diffusion and that responsible for transport of the instantaneous plume can be determined as a function of distance and meteorological variables.

Operation Mountain Iron (Air Force Sponsored) - W. T. Hinds

The final stages of the Mountain Iron diffusion program led to an equation relating exposure from a continuous ground source to ambient meteorology. The parameters yielding the best prediction were distance, source point wind direction variability, wind speed and source point temperature differences between the surface and 100 meters. This prediction model is similar to that which resulted from earlier studies by the Air Force, with the notable difference that the earlier model

~~SECRET~~

MEAN NUMBER OF 3 METER SEGMENTS* OF ARC FOR WHICH
 $\chi_i/\bar{\chi}_p$ IS GREATER THAN OR EQUAL TO THE INDICATED VALUE

Field Test	Distance From Source (meters)	$\chi_i/\bar{\chi}_p$ greater than or equal to:											
		<u>0</u>	<u>0.5</u>	<u>1</u>	<u>2</u>	<u>4</u>	<u>4.3</u>	<u>8</u>	<u>10</u>	<u>11.0</u>	<u>16</u>	<u>20</u>	<u>22.6</u>
U-47	1600	13.5	13.5	10.0	4.2	1.2		0.5	0.5		0.2	0.2	**
U-48	800	10.1	6.5	4.2	2.5	0.9		0.2	0.2	**			
U-50	800	21.9	11.8	6.8	2.8	0.3	**						

*Crosswind distance moved by sampler in one second.

**Ratio resulting from maximum χ_i .

χ_i is instantaneous concentration.

$\bar{\chi}_p$ is the 30-minute peak mean concentration.

did not include wind speed as a pertinent parameter.

The prediction equation finally derived was

$$E_p/Q_T = 0.529 X^{-1.85} \sigma_\theta^{-0.355} \bar{u}^{-0.868} (\Delta T_2^{100} + 6)^{1.14}$$

where

E_p is centerline exposure, gsec/m³,

Q_T is total mass released, g,

X is distance from source point, meters,

σ_θ is standard deviation of 10 sec averages of wind direction, radians,

$\bar{u}$ is mean wind speed, meters/sec, and

ΔT_2^{100} is temperature difference between 2 and 100 meters, °C.

The exponents on the various parameters are by and large physically reasonable. The small exponent on σ_θ is in part due to using a non-filtered value of σ_θ , which yields too large a wind variance to apply to large distances: the high frequency contribution to σ_θ is effective in diffusing the tracer only relatively near the source. The exponent on $\bar{u}$ is nearly unity, which agrees reasonably well with the exact value of unity appearing in the equation of continuity. The wind speed in the equation of continuity is an average and invariant wind which transports the tracer, so a particular choice is not necessarily accurate; the exponent 0.868 indicates that the choice of two meter height wind speed was close to the proper value. The exponent on ΔT has no theoretical justification other than sign (the positive sign is correct). The earlier equation was derived with an exponent of 4.33, an indication of sensitivity to atmospheric stability much greater than was observed in the Mountain Iron test series. The lack of sensitivity in the Mountain Iron data is at least partially due to the maritime climate involved, whereas the earlier equation was derived with a substantial amount of data from a continental diffusion program.

MARINE SCIENCESPhysical Chemistry of Ocean Solutions - R. W. Perkins

Many of the literature values for trace element concentrations of sea water are in error because of contamination problems either in sample collection or in subsequent chemical processing. Our approach has been to minimize these problems by sample collection in polyethylene containers followed by evaporation in these or other polyethylene containers and direct neutron activation of the sample in its container. This has eliminated both sampling and handling contamination problems. There are, however, some trace elements in sea water for which pre-irradiation chemical concentration processes are necessary or desirable. To investigate the contamination problems which would result from prior chemical treatment, measurements were made of the trace elements present in doubly distilled samples of various mineral acids and organic solvents, in membrane filters, in leach solutions from Pyrex and Vycor glassware, in polyethylene and polypropylene containers, and in various chelating reagents which could be used for extracting trace elements from sea water. It was observed that doubly distilled water, mineral acids and organic solvents did not contain trace elements which interfered significantly with trace element measurements in sea water. Polyethylene and polypropylene containers were reasonably clean and would not contribute significantly to trace element measurements. Acid leach solutions from the glassware contained large amounts of antimony, scandium, iron, cobalt and arsenic, the membrane filters contained large amounts of iron, zinc, antimony and chromium and the organic chelating reagents contained antimony, cobalt, scandium, zinc and copper. The use of any of these latter materials in the pre-irradiation processing of sea water could cause serious errors in trace element analysis.

RADIOLOGICAL AND HEALTH PHYSICSWhole Body Counting - R. W. Perkins

The hexagonal whole body counter which utilizes six 9 3/8 in. diam. by 4 in. thick NaI(Tl) crystals was installed in a lead room and the electronic circuits to permit anti-coincidence counting were completed. With this anticoincidence circuitry, the gamma-ray spectrum which results from single events occurring in any one of the 6 sodium iodide crystals is

recorded while events occurring simultaneously in any two or more of the 6 crystals are discarded. The precision of measurements of whole body calcium by in vivo neutron activation at the University of Washington has been limited because of the problem of obtaining uniform activation of the phantom and the standard. To date the best agreement between the phantom and the standard has been $\pm 2.5\%$ while $\pm 0.5\%$ is required. The non-uniformity of the flux field in the exposure position results from neutrons produced in the dees of the cyclotron in addition to those produced in the beryllium target by the (d,n) reaction. It is planned to investigate the neutron flux field resulting when an (α ,n) reaction is used to produce neutrons since this will eliminate neutron production in the cyclotron dees. The feasibility of the measurement of whole body phosphorus was investigated using high energy neutrons in an (n, α) reaction to produce ^{28}Al (2.3 min). Using the Van de Graaff as a neutron generator and exposing a phantom containing tissue-equivalent material, it was established that a dose of 0.005 rad would produce an easily measurable amount of ^{28}Al whereas a dose of only 0.02 rad would allow a measurement with a standard deviation (based on the counting statistics) of only $\pm 1\%$.

Radiation Dosimetry - W. E. Wilson

Design was completed and construction started on a small cave that will be used as an exposure facility to test the absorbed dose calorimeter. The effect of scattering in the cave and attenuation and scattering in the calorimeter will be determined by making measurements with small ion chambers both inside and outside the calorimeter. The ion chambers will be of tissue equivalent plastic and will be placed inside "dummy" plastic absorbers when making the measurement inside the calorimeter. The "dummy" calorimeter lines and absorbers have been fabricated in the shop.

In a comparison of Loevinger's method of calculating beta-ray doses with the theoretical calculations of Spencer, a correspondence was found that permits the extension of Loevinger's method to non-tissue materials. The results should be accurate up to $Z = 29$ and applicable to all Z though with increasing uncertainty for Z above 29.

Radiation Physics - W. E. Wilson

Emission spectra from liquid samples of acetone, benzene, xylene and toluene irradiated by 1.5 MeV protons were recorded. They agree reasonably well with data of others. Because of an equipment failure, no accurate fluorescence decay times were obtained; however, estimates indicate that all four samples decay in a few nanoseconds.

Data for the energy loss straggling of protons in tissue-like gas were reduced to probability distributions as a function of energy loss. These distributions were then compared to theoretical distributions according to Vavilov. The theoretical distributions were tabulated for only a limited number of cases, parameterized in G , the shape function. Our data did not yield exactly the right values of G for comparison so only preliminary results can be reported at this time. However, the shape is not a strong function of the parameter G and the results will probably not change appreciably with improved data. A value of $G = 0.4$ was chosen for comparison because by choosing different energies we were able to obtain this shape parameter for all four thickness absorbers that were used (0.1, 0.3, 0.5, and 1.0 μm of unit density tissue-like material). The results are in remarkable agreement with the theory considering that the theory is based on cross sections for large momentum transfers which are more important for higher energy incident particles. The fact that we are observing ionization losses rather than true energy losses may be responsible for this agreement. Or it may be that the result of the theory does not depend much on the shape of the cross section.

Film Dosimetry Calibration Laboratory Study - C. M. Unruh

All data relating to the test radiation exposures of film dosimeters from commercial processors, AEC contractors and military installations are at the computer for extensive data reduction and analysis. The dose equivalent values used in the test exposures were sent to each participant.

Statistical considerations required for comparing a film dosimeter processor's performance against performance criteria were detailed and sample data were used to study the functional value and practical workability of the method.

RADIATION INSTRUMENTSRadiation Detection and Measurement Instruments - W. G. Spear

A satisfactory blood pressure channel for the strain-gage pressure transducers for the experimental animal physiological function telemetry system was completed. The temperature stability of 1.5 Hz/°C did not prove to be adequate for the extremes of temperature change expected (0-60°C). Other forms of temperature compensation, including diode, capacitive, thermistor and feedback techniques, were tried with various degrees of success with the transistor oscillators. Other types of voltage-controlled oscillators are also being investigated. If satisfactory temperature compensation cannot be achieved using such methods, it may be necessary to apply correction curves to the pressure data by monitoring environmental temperature at the transmitter. A temperature change of at least 60°C is anticipated to occur during the seasonal changes of interest with the free-ranging animals.

Evaluation of transducer linearity data for the experimental tidal air volume monitor progressed. Some procedure discrepancies were noted, requiring additional data, which have not been completely evaluated and compared with the original information. The prototype venturi flowmeter is being redesigned to achieve better performance. With only minor electronic modifications, the instrument is now available for several diversified inhalation studies.

Development work progressed on the experimental rodent activity monitor, particularly on the design of the accelerometer sensor system. An alternative approach to the choice of position sensors was conceived. Polarized light will be utilized instead of infrared in an attempt to circumvent the heat problem encountered with the infrared sensor system. The ultrasonic sensor system arrived and developmental evaluation of this system was started.

The neutron instrument of the experimental mixed-field neutron-gamma dose rate system was tested for response to neutrons with a RaBe source. The discriminator was then adjusted so that no detectable response was observed from a ⁶⁰Co gamma source of approximately 5 R/hr. Adjustment of the discriminator in the presence of gamma was important in

establishing the interference problems of the neutron instrument. With the corrective action taken, the response to thermal neutrons is now only a factor of about 1.5 higher than it should be. However, such errors are on the safe side for the neutron unit, which uses a 10 in. diameter polyethylene sphere with five imbedded surface barrier diodes covered with lithium foils.

The preamplifier, being developed for use in in vivo detection of plutonium with lithium-drifted solid state detectors, was nearly completed in experimental form. Necessary changes were incorporated in the cryostat portion of the system and temperature calibration work was started. For best results, the field effect transistor in the first stage of the preamplifier must be about 60°F warmer than liquid nitrogen temperature. Measurements made using a commercial spectrometer system provided insight to the energy resolution capabilities. The resolution for the 20.80 keV ^{241}Am peak was 0.9 keV (L_{Y1}) and for the 13.78-13.96 keV peak ($L_{\alpha 1}$, $L_{\alpha 2}$), the resolution was 0.7 keV. When ^{239}Pu with a few ppm of ^{241}Am was counted, the resolution for the 20.163 keV peak measured 1.05 keV. The resolution deteriorates due to the presence of the unresolved 20.80 keV ^{241}Am peak.

The X-ray/alpha studies with the solid state diode detector continued with calculations made of X rays per recognized body burden levels for six different isotopic compositions. The number of X rays emitted per second per body burden amount varied from 180 for a source containing 34% ^{239}Pu to 670 for a source with 94.4% ^{239}Pu by weight. For the same sources, the X-ray/alpha ratio is 0.082 and 0.046, respectively. This shows the importance of the body burden limits in plutonium counting analysis. Due to the buildup of ^{241}Am and decay of other plutonium isotopes, the X-ray/body burden ratio of the materials containing small amounts of ^{239}Pu surpasses that of materials containing greater than 95% ^{239}Pu after "aging" for about three years.

The contoured diode detector investigations moved forward with several measurements of the background counting rate of one unit. The rate measured was 0.37 ± 0.21 count/min over a series of 10-minute counts. Two 800-minute counts resulted in rates of 0.37 and 0.39 count/minute. Attempts were made to determine the temperature dependence of the units, but electrical noise difficulties hampered the tests. A lung sample

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and some separate ^{238}Pu particles were obtained for testing with the counter. The activity of the lung sample proved to be too low, but results on the spatial resolving power of the units are being obtained for the ^{238}Pu particles. Additional sources are being prepared for further developmental evaluation studies.

Radiological Chemistry - R. W. Perkins

A new Si(Li) detector of 3 cm² surface area and 3 mm depletion depth was obtained and evaluated for application in Biology and Medicine work. This is a premium detector with a resolution of about 1 keV in the X-ray region, which is the best resolution ever obtained for a detector of this size. Using this detector a procedure was developed for measuring the amount and depth of ^{239}Pu in wounds. The decay of ^{239}Pu involves the emission of 3 X rays of 13, 17 and 20 keV. The mass absorption coefficient for the 13 keV X ray is three-fold greater than that for 20 keV X ray. The ratio of the counting rates of these two X rays as a function of depth in tissue-equivalent material shows a linear relationship and thus provides a method for measuring the average depth of plutonium in wounds and also the absolute amount of plutonium present. In a similar manner, the amount of ^{210}Pb in biological samples can be measured. The decay of this radionuclide involves only the emission of a weak beta particle, three L X rays of 11, 13 and 15 keV, and a gamma ray of 46.5 keV. A measurement of the absolute and relative counting rate of these photons from a biological sample provides the information for calculating the concentration of ^{210}Pb in the sample. Preliminary results have shown that this method is applicable in the measurement of ^{210}Pb in many samples from the Alaskan ecosystem. This is a breakthrough of major significance as it eliminates the need for the very time-consuming and complicated chemical separations which were previously required for ^{210}Pb measurements. A high resolution germanium diode was obtained and evaluated. This is a planar diode of 6 cm² surface area and 6 mm depletion depth and with a resolution of 2.5 keV at the 1.33 MeV ^{60}Co line. Although this is a relatively small diode, with its excellent resolution it was possible to identify and measure 18 airborne radionuclides on air filters. This includes some radionuclides which cannot be measured in any other manner.

Several low background construction materials have been studied in a program to determine those most suitable for fabrication of low background detector systems. Zone refined aluminum was obtained and found to contain no measurable amounts of radioactivity while the normal aluminum used as a cladding for NaI(Tl) crystals is relatively high in ^{40}K , Th and U. This material will provide an ideal cladding for sodium iodide detector systems. Pure electrolytic copper was also evaluated and found to contain a positron emitter which decayed with a half-life of approximately 17 hours. These positrons were attributed to the decay of ^{64}Cu which was produced in the copper by the natural background of neutrons in the environment. However, on placing the copper sample in the counter where it is shielded against these neutrons, the ^{64}Cu disappeared at a rate near its characteristic half-life. It thus appears that copper would also be a satisfactory cladding material where neutron shielding of the detector is provided.

A field test was conducted to demonstrate the feasibility of the noble gas atmospheric diffusion monitoring system. The detectors for this system are small geiger counters with all areas, except the windows, shielded by 1/4 inch of lead. Special preamplifiers were designed to permit transmission of the small signal from these detectors through several thousand feet of cable and still allow these signals to be of sufficient size to trigger the discriminator circuit at the data storage center. From the release of a small amount of ^{85}Kr which was observed by a detector located on the 200 meter arc, the feasibility of the system was demonstrated and it was estimated that a 10 curie ^{85}Kr release would allow measurements of the resulting plume at distances of one mile from the release point.

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