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AEC
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REPORT

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

**DIVISION
OF
BIOLOGY AND MEDICINE
PROGRAMS**

REFERENCE COPY

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PACIFIC NORTHWEST LABORATORY

RICHLAND, WASHINGTON

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(Special Distribution)

PACIFIC NORTHWEST LABORATORY
MONTHLY ACTIVITIES REPORT
MARCH 1967

Division
of
Biology and Medicine
Programs

by the
Staff of Battelle-Northwest
S. L. Fawcett, Director

April, 1967

PACIFIC NORTHWEST LABORATORY
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PACIFIC NORTHWEST LABORATORY

MONTHLY ACTIVITIES REPORT

MARCH 1967

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

RADIATION EFFECTS - GENERAL

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

Studies on an in-vitro preparation of the rat intestine indicated that sodium taurocholate influences the electrogenic transport process, which is dependent on diffusion of intracellular inorganic ions. Taurocholate does not, however, affect the glucose-dependent transport process. After 1200 R, electrolyte transport was depressed in the small intestine of both bile fistula and control rats.

Rats were prepared with external pancreatic fistulae and with external lymphatic fistulae. Irradiation of these animals and subsequent histopathologic analysis should do much to pinpoint the role of intestinal secretions in gastrointestinal injury.

TOXICITY OF RADIOELEMENTS

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

Cesium retention in newborn rats injected at birth exceeded that of the ^{137}Cs -injected adult until the young were two weeks old. From that time on excretion accelerated until, at one month, the adult retained twice as much cesium as the younger animal.

Very preliminary observations from a study in progress comparing the relative toxicities of colloidal and ionic plutonium indicated that the colloidal form is substantially more toxic to newborn, weanling and adult rats.

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

Initial laboratory experiments with fish given oral doses of ^{65}Zn confirmed the suspicions that melanin-bound zinc is not readily exchangeable. Thus, the specific activities (pCi $^{65}\text{Zn}/\text{mg}$ stable zinc) of choroid and iris tissue were found to be very low in comparison with specific activities of other tissues. Dialysis of choroid and iris against 0.1 Tris buffer, pH 7.4, containing 0.01M ZnCl_2 , also failed to show any exchange of ^{65}Zn . Preliminary studies on the subcellular distribution of ^{65}Zn in selected tissues from Columbia River fishes indicated that the soluble fraction (105,000 x g supernatant) from liver, kidney, and gill tissue contains a majority of the ^{65}Zn found in the cell, whereas in the testes ^{65}Zn is concentrated in the nuclear fraction.

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

Pooled homogenates and filtrates were prepared from spleen, liver, and blood from four animals diagnosed as having lymphocytic leukemia, and seven with myelogenous leukemia. These were inoculated into tissue culture systems, mice, and rabbits for antisera production. Electron microscopic examination of tissue culture cells inoculated with myelogenous leukemia filtrate revealed the presence of cytoplasmic and membrane associated particles that appear to be budding off the cell membrane. The particles have a dense outer coat and are approximately 100 millimicrons in diameter with a central 70 millimicron core.

Inhalation Studies - W. J. Bair

The immune response of animals following inhalation of $^{239}\text{PuO}_2$ was tested by sensitizing rats having lung burdens of about 0.05 to 0.1 μCi ^{239}Pu with sheep red cells. The heterophile antibody titer three weeks after exposure was less than half that of controls.

Biliary secretion of ^{239}Pu during the first two hours following intratracheal administration of $^{239}\text{Pu}(\text{NO}_3)_4$ ranged between 3 and 17 x $10^{-4}\%$ of the injected dose. The rate of biliary secretion of plutonium following inhalation of other chemical forms is being determined.

The phagocytosis of PuO_2 particles was studied in rats following administration of the particles by inhalation and intraperitoneal injection. Approximately 50+%, 1.3%, 6.4%, and 0.03% of ^{239}Pu administered intraperitoneally was associated with the gastrointestinal tract (mostly mesenteries), spleen, liver, and lungs, respectively, after 24 hours. Co-administration of Ca^{++} with ^{239}Pu resulted in < 2% of administered activity appearing in the peritoneal wash after 1 hour, as compared to 60+% for controls. There was a very significant relationship between the time of sampling peritoneal cells after ^{239}Pu injection and the number of tracks per particle (autoradiograms) with more tracks per particle (i.e., the largest particles) being present at 5-6 hours. Approximately 17% and 23% of lymphocytes and eosinophils were pycnotic or karyorrhectic at 24 hours, while < 3% were abnormal at 0-6 hours and at 48 hours. Co-administration of 0.02 mmoles DTPA with ^{239}Pu significantly reduced phagocytosis for the first 6 hours. Some non-significant trends were observed in the serum and peritoneal protein distribution at 24 hours. No significant differences were noted in staining for cytochrome oxidase.

Excretion Rates vs. Lung Burdens in Man

- C. E. Newton, Jr., W. J. Bair

Because of problems with target heating and long irradiation times, attempts to produce ^{237}Pu by irradiating ^{235}U with alpha particles at the University of Washington were terminated. A request for this irradiation was placed with the Lawrence Radiation Laboratory. Development of background material to support the design of experiments intended to define body burdens as functions of excretion rates continued. Arrangements were made to study excretion rates of intravenously administered plutonium fluoride in animals for comparison with excretion rates of plutonium nitrate and plutonium citrate in animals.

Space Nuclear Systems Studies - R. C. Thompson

Eleven dogs were exposed to aerosols of 50μ $^{238}\text{PuO}_2$ particles for about 10 minutes. All dogs deposited significant quantities of up to 1000 ^{238}Pu particles, but frequent scans showed rapid passage of the ^{238}Pu through the gastrointestinal tract. No ^{238}Pu could be detected in the lung region of the dogs after 1 week. In some dogs, ^{238}Pu was retained in the nasal pharynx

region for nearly a week. Nasal irritation apparently occurred in all dogs during the exposure in response to the entrance of the ^{238}Pu particles into the nose. This was characterized by excessive mucus flow.

Solubility studies on $^{238}\text{PuO}_2$ microspheres in simulated gastric juice were continued. Siliconized equipment was used to prevent absorption of Pu on glass surfaces. For reasons which are not yet clear, recent solubility determinations are substantially lower than those reported previously, varying from 1 to 6 ng $^{238}\text{Pu}/\text{mm}$. Improvements in methodology are planned for future experiments, using several particles per run and polyethylene equipment.

Plant leaves were exposed briefly to $^{238}\text{PuO}_2$ particles so that mild damage was inflicted on the leaf surface. These leaves were then exposed to nonradioactive particulates and it was observed that the deposition appeared to be greater in the damaged areas as compared to nondamaged areas.

Plutonium-Americium Studies - R. W. Perkins

A study was started to determine any variations in the biological behavior of Pu and ^{241}Am following their inhalation and deposition in the lungs. A procedure was developed which allows the direct electrodeposition of Pu on a Pt disk from an ashed biological sample with a yield greater than 98%. A procedure was also developed for the simultaneous electrodeposition of Pu and ^{241}Am . The combined use of these procedures will allow the absolute measurement of Pu and ^{241}Am in various biological samples. A direct instrumental method is being investigated for the direct measurement of Pu and ^{241}Am in ashed biological samples. This method involves counting the Pu X rays and the 60 keV ^{241}Am gamma ray emitted from a sample with a Si(Li) diode. Although the feasibility of the method was demonstrated, the ultimate precision which can be achieved on samples will determine its practicability for actual biological samples.

Biological Systems Model Development - R. D. Benham

^{65}Zn Transport in the Limpet Snail. A FORTRAN program was written to determine the rate of uptake of algae by the limpet snail as function of time. Library studies were also made to

determine the mechanisms involved in the uptake and elimination of ^{65}Zn by the algae. Further analog studies were made on the variation in ^{65}Zn production assuming constant reactor power level. The FORTRAN program used assumes that ^{65}Zn is assimilated at the same rate during the whole life cycle of the limpet (i.e., a young limpet assimilates the same amount of ^{65}Zn as does an older limpet). The computed results show that this does not appear to be a good assumption because of the large variation in eating rate that it would require. Biological studies are needed to find how the rate of zinc assimilation varies as a function of zinc concentration in the food base, the age of the limpet, and the time of year. It should also be determined whether ^{65}Zn and normal zinc are differentiated in the metabolic cycle of the limpet. Also needed is a determination of how much of the limpet's total burden of ^{65}Zn is contained in the alimentary canal in the form of ingested algae of high ^{65}Zn concentration and how much of the ^{65}Zn burden is actually contained in the tissues of the limpet.

The eating rate of the limpet was calculated from computer-generated curves. The observed concentration in the limpet at any time was decayed for one week and then this value was compared to the actual concentration observed in the limpet at the end of that week. The difference between the two concentrations is then indicative of the amount, A , of algae the limpet must have assimilated each day in order to achieve its present concentration level. Assuming that assimilation takes place at a constant rate, the eating rate, E_r , of the limpet (in grams algae per gram limpet weight per day) is proportional to A (i.e., $E_r = K A$).

Three methods of simulating the ^{65}Zn concentration in river water were tried but none agreed with the observed data. The first method assumed reactor output of ^{65}Zn to be constant. The second method assumed that the output of ^{65}Zn varied directly with the normal Zn concentration observed in the river water. The third method assumed that the ^{65}Zn output varied with the normal zinc concentration, but that there is a maximum ^{65}Zn output which is never exceeded.

Lung Model Development. A lung model is being developed which will be used to calculate initial deposition of plutonium in the deep lung given excretion data. The biological elimination

rates were increased for the stomach, small intestine, and large intestine. The biological half-times were shortened to one hour for the stomach, four hours for the small intestine, and 18 hours for the large intestine. The values for the biological half-times were obtained from the literature. These values are estimates for the standard man but yield good results for the beagle dog data we have.

A major modification was made to the lymph compartment in that it was split into two compartments. The quantity of radionuclide within the two subcompartments is summed to yield the total contents within the lymph compartment at any point in time. The first of the two subcompartments retains 9/10 of the total amount of radionuclide received by the lymphatic system. There is no decay constant associated with this compartment. The remaining 1/10 is fed to the second subcompartment which sends the radionuclide with a biological half-time of 1 year into the blood stream. A more detailed lymph model was considered with the bronchial and mediastinal nodes each having the 9/10 and 1/10 compartments. The mediastinal lymph nodes are downstream from the bronchial lymph nodes and since the mediastinals receive only 1/10 of that received by the bronchials from the deep lungs, the contribution by the mediastinals to the overall lymph picture is quite small and can be ignored.

The deep lung or pulmonary compartment of the model and the data from the report literature matched extremely well. The lymph compartment data indicate that the model should be adjusted so that the contribution from the "slow" pulmonary compartment is increased. However, the lymph compartment was modelled after data from Bair et al., so it becomes a matter of choosing which set of data to match.

The liver and bone data are of such low level that there is much variation. It is hard to make conclusions on the liver. If one were made, it would be to raise the amount entering the liver from the blood. The conclusion that may be reached as far as the bone compartment is concerned is that the quantity in the bone is still increasing after five years.

Of major concern in the model is the blood compartment. Physiologically this compartment is very important since the vascular system transports the radionuclide to so many organs within

the body. There are few blood data available and the published values vary widely. There are no data available which show the quantity of radionuclide in the blood during the first 12 hours after exposure. Our model indicates that the maximum concentration in the blood occurs at about two hours after exposure. It also shows that the amount of radionuclide in the blood drops quite rapidly to zero and remains there. This is not true biologically since there are organs like the bone, liver, and kidney which under chronic or long-term experiments feed small amounts of the radionuclide back to the blood; analysis of blood samples taken at any time after the first day or two should show small traces of radionuclide. Bioassays do indeed show this, but the small samples taken yield highly variable data.

The decision was made to feed the bone, liver, and kidney outputs into a long term blood compartment. This was done and a decay term was used to cause the long term blood to remain constant. When this was accomplished, it was noted that the bone and liver compartments built up at a slow rate while the kidneys decreased. This seemed reasonable since the kidneys have the urine as an output and the bone data show an apparent rise.

MOLECULAR AND CELLULAR LEVEL STUDIES

Cellular Regulatory Mechanisms - W. H. Matchett

Preparations of ribonucleoprotein particles were examined from the point of view of sensitivity to the RNA degrading enzyme, ribonuclease. These studies showed that the particulate fraction which we had previously designated as ribosomal precursors, is approximately ten times as sensitive to ribonuclease digestion as is the particulate fraction which we previously identified as 50S ribosomes. The particles designated ribosomal precursors were also shown to contain both 23S and 16S RNA. Thus, the particles which we have isolated and identified as ribosomal precursors would seem to meet at least two of the generally recognized criteria of such particles.

In another experiment, cells of Escherichia coli grown under several conditions for many generations in the presence of radioactively-labeled uracil were mixed with a large excess of non-radioactive cells which had undergone a period of chloram-

phenicol inhibition. Extracts of the cell mixtures were prepared and examined on sucrose density gradients before and after partial digestion with ribonuclease. Differences in the radioactivity profiles are observed under such conditions. Ribonuclease-sensitive material will not appear on the gradients prepared from extracts which had been challenged with ribonuclease. Such an assay method allows one to determine the amount of ribonuclease-sensitive material at any given position on the gradient. The amount of ribonuclease-sensitive material exhibiting sedimentation values between 25S and 45S would, therefore, appear to be a measure of the amount of immature ribonucleoprotein material. Using this method, we find an inverse relationship between the amount of ribosomal precursor material and the relative rate of RNA synthesis. This finding is in accord with previously reported deductions based on other results.

Methods were developed for the measurement in Neurospora crassa, in vitro, of amino-acyl-sRNA synthetase. We have successfully demonstrated the activities of leucyl-sRNA synthetase and are now working on the isolation of various intermediates in the histidine biosynthetic pathway. We shall measure the effects of these compounds on the charging of tryptophan to its sRNA.

Recent experiments have shown that the level of the tryptophan transport system in Neurospora is markedly affected by the concentration of tryptophan present in the growth medium. When exponentially growing cells were incubated for three hours in 3 mM tryptophan, transport activity for leucine and tryptophan were decreased to 1/5-1/6. The implication is that the concentration of tryptophan in the growth medium serves as a stimulus for the regulation of the level of tryptophan transport system and thus the rate of tryptophan uptake.

Reports in the literature suggest that the transport system for amino acids in yeasts possesses different biochemical specificities which depend on the nature of the source of nitrogen in the growth medium. Preliminary experiments with Neurospora, using glutamate as a sole nitrogen source instead of ammonium ion, showed a decrease in the K_m for both leucine and tryptophan transport.

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

Investigation of transient species formed during the irradiation of the artificial food coloring, FD&C Blue No. 1, in aqueous solution was continued both by electron spin resonance spectrometry in the γ -irradiated flow system and by optical spectrophotometry following pulse radiolysis with 2 MeV electrons. This compound, an efficient chemical protective agent for several biochemical systems, was earlier found to form relatively stable free radicals in oxygen-free, irradiated solutions containing 1N sulfuric acid and 0.5M ethanol. It was now discovered that these radicals could also be detected in neutral solutions if ethanol were present and the time between irradiation and examination decreased. The ESR signals could still be observed, however, for at least 30 minutes, and the disappearance of the radicals was again found to be a bimolecular process. Introduction of molecular oxygen caused the radical signal to disappear immediately. The evidence suggests that the radical observed is the reduction product of the dye with the $\text{CH}_3\dot{\text{C}}\text{HOH}$ radical derived from ethanol by hydrogen abstraction with hydroxyl radicals. Further support for this conclusion was found by saturating the solution with nitrous oxide to convert hydrated electrons into hydroxyl radicals and noting that the concentration of dye radicals increased.

Further decrease in the time between irradiation and observation of the dye solutions was achieved by a rapid spectrophotometric examination following pulse radiolysis. Using a 1 millisecond pulse of 2 MeV electrons to deliver 1500 rads, a transient spectrum with an absorption peak at 460 nm was observed even in the presence of molecular oxygen. The decay was again a bimolecular process; however, the absorption spectrum of this species must now be compared with that of the free radical formed in the absence of oxygen.

ENVIRONMENTAL RADIATION STUDIES

Eskimo Food Chain Studies - R. E. Nakatani

Cesium-137 body burdens were again measured at Anaktuvuk Pass, Arctic Village and Ambler during 1-17 February. Results were as follows:

^{137}Cs Body Burdens of Adult Alaskan Natives

<u>Location</u>	<u>N</u>	<u>^{137}Cs Body Burden (nanocuries)</u>	
		<u>Mean + SE</u>	<u>Range</u>
Anaktuvuk Pass	19	510 $\pm$ 46	240-1100
Arctic Village	17	190 $\pm$ 24	70- 380
Ambler	26	830 $\pm$ 80	300-1760

The Anaktuvuk Pass values were about 17% below those of December and follow the expected pattern, which we initially defined during the period January 1964-August 1965. Comparing current data with that period, it appears that the coming summer will see lower human values than last year unless there is a recurrence of unusually high ^{137}Cs concentrations in caribou flesh, such as occurred in the spring of 1964.

Arctic Village adults contained about half as much ^{137}Cs as in December, due to their having practically no caribou since November. They do not expect to kill any more caribou until the spring migration in April-May. Under normal conditions the seasonal pattern of ^{137}Cs body burdens of the Arctic Village people should be more like that of Ambler residents, who continued to increase their ^{137}Cs body burdens by about 40% over December as they eat fresh caribou from the nearby winter caribou range.

Lichen samples were obtained from winter caribou ranges on the Selaivik River, from 40 miles south of Anaktuvuk Pass and from the usual sampling site at Anaktuvuk Pass.

Terrestrial Ecology - R. E. Nakatani

Radiochemical determinations of ^{90}Sr in the vegetation of a mountain bog have been completed and provide interesting contrasts with the data previously obtained in regard to ^{137}Cs . Sedges growing in water 2-3 dm deep had more ^{137}Cs than did the same species growing in the less aquatic situations near the bog margins, but the long-lived mosses showed the opposite trend and had their highest concentrations of ^{137}Cs at the bog margins. Sedges growing in deep water had more ^{137}Cs than did the moss in the same environment. This pattern was not observed for ^{90}Sr .

Mosses were higher in ^{90}Sr than were sedges regardless of location along the moisture gradient. These observations imply that ^{90}Sr is not as biologically mobile as ^{137}Cs in bog habitats. Most data on terrestrial vegetation would indicate that ^{90}Sr is more mobile than ^{137}Cs .

A preliminary trapping operation, designed to evaluate the most efficient spacing of traps, tagging techniques, and handling procedures, was completed. The results of this pilot study were used to design a 4 hectare study area, which was surveyed prior to distribution of 400 live traps, marker stakes, and trap covers.

An experiment testing the response of Microtus oregoni to acute ionizing radiation was completed and the data gathered are being prepared for computer processing. A second experiment was begun utilizing Perognathus parvus, to further document the relatively low LD_{50/30} value obtained last year.

Plant Uptake of Radionuclides - F. P. Hungate

Bean plants were grown to the third trifoliate stage in nutrient solution and then exposed to ^{241}Am and ^{239}Pu for 3 days, after which they were harvested. Leaf to root ratios of 0.0002 and 0.008 were obtained for ^{239}Pu and ^{241}Am , respectively. Corresponding leaf to solution ratios were 0.00005 and 0.003. Since ^{239}Pu frequently is contaminated with approximately 2% ^{241}Am , this approximately 50-fold higher uptake of americium than of plutonium leads to plants having as much alpha count from americium as from plutonium, even though the ^{239}Pu constituted 98% of the material to which the plant was exposed.

Columbia River Ecology - R. E. Nakatani

The regular sampling schedule was curtailed with the completion of one year's sampling. Emphasis is now being placed upon data processing and analysis.

Temperature Effects on Metabolism of Aquatic Organisms - R. E. Nakatani

Tubifex exposed to water containing different concentrations of ^{65}Zn at three holding temperatures (5, 15, and 20°C) did not

show a large effect of temperature on ^{65}Zn uptake. The data are still very limited but early results indicate a relatively rapid turnover of ^{65}Zn in these worms. The half-life estimates average about 17 days, with little effect of temperature.

Earth Sciences - W. A. Haney

Seven minor quakes have been detected and identified as centering in the southern part of the Columbia Basalt Plateau in the last two years. Only four were strong enough to permit an epicentral determination. Those four, including the recent Mabton quake, seem to be associated with the Horse Heaven Hills and the Blue Mountains.

Several persons in recent years have promoted the concept of an Olympic-Wallowa Lineament that represents a major structural discontinuity and a major fault zone along which earthquakes have occurred and will occur. The Lineament passes through the Horse Heaven Hills at Wallula Gap. The occurrence of earthquakes well away from the Gap and the recently determined lack of major structures in the Horse Heaven Hills there de-emphasize the significance of the Lineament there as a major fault zone.

Evaluation of the project ground water flow system and the effects of boundary condition changes on the system require functionally fitting the predicted water table surfaces for each of the boundary conditions. In an effort to expedite the functional fitting, the difference surfaces (the difference in hydraulic potential between the present water table surface and the predicted surface) were fitted. The difference surfaces tend to be more regular and less undulating than the actual surfaces themselves, thereby making it easier to obtain an accurate functional representation. The equation of the difference surface is then added to the equation of the present water table surface to obtain the equation of the predicted surface.

The abundance of data obtained from the "Steady" solutions has resulted in accurate representations of the difference surfaces even though severe conditions occur in the surfaces near the large boundary condition changes. However, the abundance of data has uncovered two weaknesses of the computer program "Genoro" that occur when using great amounts of data and large numbers of terms; these are errors in orthogonalization and limitation of

storage capacity of the program. In addition to being able to use constraints to help fit surfaces, the new fitting program "conifer" will eliminate these weaknesses of "Genoro."

ATMOSPHERIC RADIOACTIVITY AND FALLOUT

Radioisotopes as Particles and Voltatiles - L. C. Schwendiman

Particle flux as a function of radial position in a 1.15 in. inside diameter tube was measured by examining the filter loading distribution of monodisperse uranine particles. A constant Reynolds number of 23,800 was used in an effort to identify the influence of particle size and to relate the flux profiles to the effective deposition velocity. Earlier studies with a 2.81 in. diameter tube showed that a high flux of particles in a region near the wall was associated with re-entrainment, yet under conditions compatible with increasing effective deposition. The recent studies with the smaller diameter tube again showed that particle loadings as large as 1.5 times the average occurred in an annulus within 0.2 in. of the tube wall. A progressive increase in the normalized flux from 0.9 to 1.5 occurred as the particle size was increased from 1 micron to about 9 microns. Further increase in particle size up to 26 microns was accompanied by a progressive decrease in normalized flux until a value of 1.1 was reached. The progressive decrease was accompanied by a concurrent decrease in effective deposition velocity, showing that re-entrainment for particles larger than about 6 to 8 microns was very significant. Most significant was the great increase in effective deposition velocity when particle size increased from 2 to 5 microns. Five-micron particles also appeared to be near the size at which the relative flux in the annulus near the wall rose to 1. The interrelationships between particle concentration profiles in the body of the gas and the deposition velocity and re-entrainment must be known before a universal deposition model can be achieved.

The control instrument panel for the high speed spinning disc generator was designed and the necessary controls were obtained. Conditions for achieving sphericity and uniformity of particles were explored with the primary variable investigated that of percent of uranine and methylene blue in the particle produced. Results indicated that high quality monodisperse

aerosols could be produced with greater than 50% uranine by weight.

An aerosol, nominally 2.8 microns in diameter, was used to study the stage efficiencies of a circular nozzle seven-stage commercial impactor. According to the manufacturer's calibration 100% of uranine would deposit on stages 4 and 5. This was essentially the observation--about 5% of the mass present deposited on stage 6 and was confirmed to consist of the primary rather than the satellite (about 0.7 micron) particles. Efforts to improve the retentivity of the 4 and 5 stage and to sharpen the cut-off were not successful. A method for accurately measuring the mass associated with satellite particles using particle inertia difference was not achieved. Other methods are being studied.

Atmospheric Tracer Development - R. W. Perkins

A field demonstration of the feasibility of real-time analysis of atmospheric dispersion was successfully carried out. In this test a small amount of ^{85}Kr was released as a puff at the apex of the meteorological grid and the counting rates observed from two geiger detectors located on the first arc of the grid were measured as a function of time. The data provided a precise record of counting rate as a function of time and thus demonstrated the feasibility of the noble gas atmospheric diffusion monitoring system. A stepping generator for this system which will allow counting durations of 0.75, 1.5, 3 or 28-second counting intervals from 64 field detectors were designed. For any one of these pre-set times it will automatically initiate a counting sequence and store information in consecutive 64-channel groups of the computer memory. This system will thus allow real-time measurements from a set of 64 field detectors.

In evaluating ZnS as a tracer of atmospheric precipitation scavenging it was necessary to determine its phosphorescent properties in water. Compared with its phosphorescence emission from the normally used ethyl acetate mixture, its phosphorescence in water is one order of magnitude lower at the detection limit. This detection efficiency (about 2×10^{-8} g) is still adequate for many precipitation-scavenging studies.

Radioactive Fallout Rates and Mechanisms - R. W. Perkins

By use of a 300 mm², high-resolution Si(Li) detector, the feasibility for the direct measurement of ⁵⁵Fe and ²¹⁰Pb on air filters was demonstrated. Iron-55 is measured from its 5.9 keV X ray while the ²¹⁰Pb is measured from the 11, 13 and 16 keV X rays and the 46.5 keV gamma ray, which are emitted in its decay process. Previous measurements of these radionuclides in air filters have required very tedious and time consuming radiochemical separations and have, therefore, been performed on only a limited number of samples. Standardized counting geometries for air filters are being calibrated so that the ⁵⁵Fe and ²¹⁰Pb on air filters, collected during the past several years, can be measured.

In initial high altitude air sampling studies, it has been possible to make direct measurements of the cosmic-ray produced ²⁴Na at altitudes between 65,000 ft and ground level. This is the first measurement of a short-lived cosmic-ray produced radionuclide above ground level and provides a basis for defining the absolute production rate of ²⁴Na, which is essential for its full utilization as a tracer of precipitation scavenging process.

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

In studies with a new large-area, high-resolution Si(Li) diode the feasibility of measuring ⁵⁵Fe by direct counting of many environmental samples was demonstrated. On an ashed sample of salmon tissue, it was possible to measure the iron content from its 5.9 keV X-ray peak with a standard deviation of only $\pm 3\%$. This is a better precision than previously achieved with radiochemical separation procedures. It was also demonstrated that ⁵⁵Fe can be measured directly in caribou liver, blood, and in air filter samples. This instrumental analytical technique will greatly extend the type and number of samples which can be studied.

Measurements were made of ⁵⁵Fe and stable iron in several samples of plankton and fish taken at depths between the surface and 2,800 meters at 40 to 60 miles off the Oregon coast. The variations in concentrations of both ⁵⁵Fe and stable iron among the various marine species in this depth range were less than a

factor of 6. The average ^{55}Fe specific activity in these samples was relatively low, 0.015 nanocurie per kilogram. This value can be compared with the specific activity of 9.2 (about 700 times higher) for salmon from the West Coast.

The first set of mother-fetus blood samples was analyzed for ^{55}Fe in the joint study with Dr. J. M. Aase of the Arctic Health Research Center. In these studies, blood samples are taken from the mother, while fetus blood is taken from the placenta, after birth of the child. The objective of these studies is to determine if ^{55}Fe in the fetus is in equilibrium with that of the mother. The initial measurements show equilibrium within the $\pm 10\%$ inherent analytical error. Several other analyses will be necessary to establish if this apparent equilibrium condition is typical and if any variations exist.

Radioanalytical Procedure Development - R. W. Perkins

A simplified radiochemical separation procedure was developed for the measurement of cosmic-ray produced chlorine radionuclides in rainwater. As rainwater is collected on a large polyethylene sheet, it is drawn through a freshly-formed silver chloride sorption bed, which quantitatively removes ^{34}mCl , ^{38}Cl and ^{39}Cl . This eliminates the need for precipitation of chlorine isotopes from large volumes of rainwater in measurements of these cosmic-ray produced radionuclides in precipitation scavenging studies.

Fallout Phenomenology - W. E. Davis

Work was continued on the details of isentropic trajectories in and below the nuclear cloud for Shot Smoky. An arrival time predicted by upper level isentropic trajectories at a point 170 miles downstream from the point of detonation was confirmed within 12 min by a visual observation. Further check on the isentropic trajectories below the base of the cloud indicated an arrival time at Rock Springs, Wyoming, concurrent with shower activity. It is suggested that the observed hot spot (area of anomalous high dosage in the fallout pattern) in the Rock Springs area could have been due to wash-out.

Transport and Diffusion - W. T. Hinds, C. E. Elderkin

Analysis of real time sampler (RTS) data gathered for 8 and 15 min periods during two wake study tests in slightly stable conditions was extended to include the time history of concentration fluctuations. The concentration traces on the RTS recorder were smoothed over increasing time intervals from five seconds to several minutes. Each smoothed peak concentration was divided by the mean concentration for the entire period of record forming peak-to-mean concentration ratios (P/M) for each smoothing (averaging) interval. The P/M data were observed to have a power-law dependence on averaging interval, the index being negative and less than unity. The P/M relationship to averaging time in the wake of a building was seen to lie between data given in the literature for ground and elevated sources.

Assay of four of six dual tracer diffusion tests where simultaneous releases were made from the surface and from 85 ft was completed and their initial analysis performed. Two of these tests were conducted in unstable conditions and one each in neutral and slightly stable conditions. The two unstable tests demonstrated nearly identical results for both surface and elevated sources. The neutral test showed similar exposure characteristics though, as expected, exposures were somewhat higher than for the unstable tests. A striking difference was observed for the stable test elevated release. Although exposures from the surface source were comparable for both the neutral and stable tests where mechanical turbulence generated at the surface controls the diffusion, the elevated-source peak exposure for the stable case was markedly reduced and the distance to that peak was significantly increased. This observation is attributed to the dampening effect of stability on the convective turbulence, thus removing the dominant mechanism for diffusion above the surface.

The 85 ft source exposure data were compared with existing data from the 185 ft source using a previously discussed normalization procedure, verifying the applicability of the procedure at another height. In addition, maximum values of crosswind integrated exposure from the two heights were compared to the bivariate normal model for an elevated source with the encouraging results shown below.

<u>Source Height</u>	<u>Observed CIE_{max}</u>	<u>Theoretical CIE_{max}</u>
85	1.44×10^{-2}	1.87×10^{-2}
185	8.0×10^{-3}	8.6×10^{-3}

Precipitation Scavenging - D. I. Hagen

Two washout tests utilizing AgI and Br tracers were conducted in snow on February 15, 1967. An additional test was conducted utilizing AgI only in snow on February 16, 1967. These tests are designated as R-29, R-30 and R-31, respectively.

Washout coefficients for AgI for Tests R-22, R-23, R-24, R-25, and R-26 were calculated and are presented in the table with associated snowfall rates (water equivalents).

Washout Coefficients for AgI in Snow

<u>Test</u>	<u>Sec⁻¹</u>	<u>R, mm/hr</u>
R-22	$9.04 \times 10^{-6} \pm 50\%$	4.5
R-23	$5.8 \times 10^{-6} \pm 50\%$	2.5
R-24	$6.4 \times 10^{-6} \pm 50\%$	1.1
R-25	$3.3 \times 10^{-6} \pm 50\%$	1.8
R-26	$4.3 \times 10^{-6} \pm 50\%$	0.44

Washout coefficients for Tests R-24 and R-26 are higher by a factor of 3-4 than expected from previous results. Since these tests were conducted from releases at heights of 20-30 ft and sampled downwind about 100 ft, it seems likely that dry deposition has occurred. Low release heights are necessary in winds greater than 2 mph to insure that the collected snow has indeed passed through the plume. Investigations of the importance of dry deposition in producing errors in the rain samples began with a test conducted March 10, 1967, with all conditions similar to those existing during the conduct of washout tests with the exception that there was no precipitation.

A method of releasing iodine as a tracer for scavenging experiments was developed which avoids previous problems of recrystallization of I_2 out of a dense plume and uneven generations. The generator simply atomizes a solution of alcohol

and iodine with the aid of compressed air or nitrogen. The atomized droplets quickly evaporate leaving a thin plume of iodine gas. A release rate of 600 g iodine/hr was found to be possible.

MARINE SCIENCES

Physical Chemistry of Ocean Solutions - R. W. Perkins

To avoid contamination in the trace element analysis of ocean water, samples are collected in polyethylene containers, but some absorption of the trace elements on polyethylene surface does occur. Initial studies using radioactive tracers of In, Co, Zn, Sb, and Cs indicated the order of magnitude of loss. When an ocean water sample was allowed to stand for 7 days in a polyethylene container, about 80% of the In, 20% of the Sc, and smaller amounts of the Co, Zn, and Sb were lost; however, no measurable loss of the Cs occurred. These observations may explain the fact that In has never been detected in seawater. A radiochemical procedure for the separation of In from seawater was developed which involves solvent extraction into a 8-hydroxy quinoline chloroform solution. This relatively simple procedure, coupled with proper sample handling, should allow the precise measurement of this rare element in seawater.

RADIOLOGICAL AND HEALTH PHYSICS

Whole Body Counting - R. W. Perkins

The hexagonal whole body counter, which consists of six 4 in. x 9 in. sodium iodide crystals in a circular array, was modified to permit coincidence and anticoincidence counting of a subject. With the point source of ^{60}Co at the center point of the detector system, the 2.5 MeV addition peak is reduced sixfold when coincidence events between any two of the 6 detectors are cancelled. An additional advantage is that the background is reduced by 20% in this anticoincidence mode of operation. The problem of the "end" effect in whole body scanning has been compensated for by use of a speed reduction drive which exactly compensates for the smaller sample field

of view as the detector reaches the end of a subject. This technique will allow uniform responses from radionuclides in a subject without the necessity of massive collimation.

An evaluation was made of the large multidimensional gamma ray spectrometer, which employs two 11 in. diameter by 6 in. thick sodium iodide crystals in a plastic phosphor anticoincidence shield, for the measurement of ^{131}I in the thyroid. Although this technique provides a twofold greater sensitivity than any other known technique for thyroid ^{131}I detection, it is evident that a smaller detector system designed specifically for this purpose would provide an even greater sensitivity improvement.

In development work on in vivo neutron activation analysis at the University of Washington cyclotron, it was demonstrated that a much more uniform neutron flux could be achieved by use of the (α, n) rather than the previously used (d, n) reaction. With the (α, n) reaction the stray neutron flux from the cyclotron dees was eliminated and a linear relationship between beam current and neutron flux was achieved. Flux monitors placed at the normal subject position and the standard sample position indicated that the flux was constant to within 1%.

Radiation Dosimetry - W. E. Wilson

Measurements to determine the effect of the position of the phantom used in the Walla Walla project on monitor count per unit dose and to confirm earlier dose distribution measurements in the region of interest were completed for 2 MeV neutrons. With the phantom facing inward, an increase of 5% occurs in calibration when the phantom is shifted right. Similarly, an increase of 8.7% occurs when the phantom is shifted left. Moving just the upper torso to the left causes an increase of 9%, while removing the left arm causes a 3% increase. An 8% difference was noted for the central (standard) position between operating days. With the phantom facing outward, the monitor counts-per-unit-dose are 30% lower than when facing inward, but shifting the upper portion of the phantom causes no changes in calibration. However, removal of either lower leg causes an increase of 13%. In addition to the position effect trials, a series of tests was made to calibrate the ion chambers against a tissue equivalent flow chamber.

Radiation Physics - W. E. Wilson

Preliminary measurements were made using argon gas in the target cell of the Van de Graaff. The argon emission spectrum, like that of helium, is quenched at high pressures. Again we were troubled by nitrogen impurities in the target cell. There seem to be two different energy transfer processes between argon and nitrogen. This is in contrast to the apparent single process for a helium-nitrogen mixture. The two processes might be:

Another possible process that has not been considered yet is the excimer process but the data have not yet been interpreted using this model.

Film Dosimetry Calibration Laboratory Study - C. M. Unruh

The establishment of film dosimeter performance criteria continued with computer analysis for all the test irradiation data provided by commercial processors, AEC Contractors and military installations. Some significant data bias on both the high and low side of the average test exposure irradiation levels were noted. In spite of the bias, the variances observed were generally good. These observations tend to indicate that a bias correction or change in calibration standards can significantly improve some film dosimetry services.

RADIATION INSTRUMENTS

Radiation Detection and Measurement Instruments - W. G. Spear

Improvements continued on the instrument for the measurement of mixed-field, neutron-gamma dose rates. The neutron monitor count rate was adjusted to give correct dose rate information with two separate sources of neutrons, Pu-Be and PuF₄. The adjustment was necessary because the discriminator level had been increased to eliminate all visible response from a 3.3 R/hr gamma source. Further field testing was planned.

Design criteria were formalized and capital equipment requests initiated for the final experimental model of the tidal volume air monitor. The system will be flexible enough to support several projects and fill specialized needs in the Biology Department.

Redesign of the voltage controlled oscillator (VCO) of the blood pressure channel for the animal physiological function telemetry system resulted in a maximum pressure drift of ± 9 mm Hg over the anticipated pressure range of from 0 to 300 mm Hg for the temperature range from 10 to 60°C. By adding transmitter temperature monitoring capability to the system, correction to ± 3 mm Hg will be possible. In order to limit drift in the VCO due to battery aging effects to ± 2 mm Hg, a voltage regulator for the power supply was designed. Other improvements are being incorporated into the tunnel diode oscillator circuit of the output stage. Field tests were planned to evaluate the improvements as soon as the modifications can be completed.

The intrinsic efficiency of the surface-contoured diode was measured for several isotopes with low energy photons. For the ²³⁹Pu X rays (17 keV average energy), the intrinsic efficiency is $4.8 \pm 0.5\%$; however, the efficiency reduces to $2.2 \pm 0.15\%$ at 5.9 keV (⁵⁵Fe) and to 0.53% at 4.9 keV (⁵¹Cr). This reduction at lower energies is due to a thick dead layer that absorbs many of the incident photons. The low energy response can be increased by etching the surface of the diodes; however, tests with the "etched" diode received from the supplier indicated that the efficiency was no better. Investigation of the trouble indicated that the wrong unit had been shipped. A new diode assembly is now being obtained. The diode also has

a thin sensitive layer such that the efficiency for ^{241}Am (60 keV) is only $0.54 \pm 0.04\%$. The geometrical efficiency of these units is also low since there is such a small sensitive area. In tests with a 0.025 in. collimator on the detector, ^{238}Pu particles about 1.0 mm apart could be differentiated. Particulate size ranged from 10 to 49 microns while the activity varied from about 0.1 μCi to about 10 μCi . By placing the detector within 2 mm of the sources, the geometrical efficiency was such that one-minute counts could be taken.

A commercial preamplifier, modified such that the input stage can be cooled, is the first of three preamplifiers to be completed and tested for use in in vivo plutonium detection. Front-end temperature is -168°C , which is approximately 20°C cooler than optimum; however, the expected improvement at -148°C is less than 10%. Gamma and X-ray spectra were observed using ^{239}Pu , ^{99}Mo and ^{133}Ba sources. The best resolution achieved to date is 1.8 keV (FWHM) for the 17 keV plutonium X ray. A second unit, a different preamplifier, is now complete and ready for tests.

Containers in which to store the X-ray/alpha study LID germanium detectors at liquid nitrogen temperatures and under vacuum were completed and are now in use. Lead seals replaced the original copper ones and improved sealing resulted. A system to reactivate the molecular sieves was designed and is now being fabricated.

Radiological Chemistry - R. W. Perkins

A large volume-high resolution Ge(Li) detector was obtained and shown to be extremely practical for the measurement of trace elements in biological tissues by neutron activation analysis. This diode is a coaxial-drifted detector with an active volume of 20 cm^3 and less than 5% uncompensated volume. When operated with a Camberra preamplifier model #1408 A, a Tennelec TC200 amplifier, and a Nuclear Data 2200 series analyzer, a resolution of 3.47 keV for the ^{60}Co 1.33 MeV line was achieved. From the gamma-ray spectrum of neutron irradiated lung tissue measured 3 months post-irradiation, the 12 radionuclides, ^{46}Sc , ^{51}Cr , ^{54}Mn , ^{59}Fe , ^{60}Co , ^{65}Zn , ^{75}Se , ^{86}Rb , ^{110}mAg , ^{124}Sb , ^{134}Sb , ^{134}Cs , ^{203}Hg could be measured with reasonably good precision and from these measurements the

concentrations of 11 trace elements could be calculated. In addition, phosphorus can be precisely determined from its bremsstrahlung component of this spectrum, and if measurements are made after a shorter decay period (2 to 3 weeks) sodium and bromine are easily measured from the characteristic gamma radiation of their radioactive daughters. This method for the direct measurement of trace elements in human tissues will allow the practical investigation of the natural abundance and the biological behavior of trace elements in the body. Direct applicability to a wide variety of biological and environmental materials also appears certain.

Germanium diodes have been found to be extremely useful in the measurement of radionuclides in reactor effluent water. In addition to being able to measure most of the radionuclides which are normally measured by multidimensional gamma-ray spectrometry, the long-lived radionuclides ^{152}Eu (12.4 y) and ^{160}Tb (72 d) are well resolved. This is the first direct measurement of these rare earths in reactor effluent water by instrumental analysis. The use of even this large diode for such measurements does require rather large samples and long counting periods and a study of effluent water radionuclide behavior in the Columbia River would require extremely large samples with the relatively small diodes presently available.

Background studies with the new Si(Li) diode indicated a major contribution from the ^{232}Th chain. Further studies isolated the source of this contamination to the Be window of the diode. Replacement of this window with a "clean" Be window should reduce the background to about one-third.

The direct measurement of ^{210}Pb in many biological samples by use of either the high resolution Si(Li) or Ge(Li) detectors was demonstrated. With the Si(Li) detector, both the X rays and the 46.5 keV gamma ray associated with ^{210}Pb can be observed and the relatively counting rates of these photons provides a measure of their internal attenuation. This technique was successfully demonstrated on Alaskan samples of caribou bone, liver and lichen. In addition to the characteristic radiation from ^{210}Pb , X rays from ^{55}Fe , $^{110\text{m}}\text{Ag}$, ^{127}Te , ^{137}Cs are apparent in some of these materials and can be used in estimating their concentrations.

Preliminary investigations of the trace elements in water and soil samples from the Central American canal zone sites are being made. Three water samples and four soil samples were neutron irradiated and their trace element composition is being determined. These samples are the forerunners of the actual program samples presently being collected by the Ecology Section in the Canal Zone and are being used to determine approximate levels and analytical techniques. Six new Geological Standards have been obtained from the U. S. Geological Survey and are being analyzed. These samples are also being analyzed by several other laboratories and will thus allow a comparison of our neutron activation analysis measurements with those of other laboratories.

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