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METALLURGICAL PROJECT

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METALLURGICAL LABORATORY

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* * *

HEALTH DIVISION

R. S. Stone, M.D. - Director
C. J. Watson, M.D. - Associate Director

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REPORT FOR MONTH ENDING DECEMBER 25, 1943

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HEALTH DIVISION
R. S. Stone, M.D. - Director
C. F. Watson, M.D. - Associate

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ABSTRACTS

A. Clinical Medicine and Medical Research

During the month, the Liaison Committee made 33 special surveys. As a result of these surveys, 7 individuals were referred to the Clinics of Billings Hospital. Mr. Cunningham's group has been working almost exclusively with active materials during the past month. One of this group showed a diminished white blood count which was felt to be due to radiation. Removal from exposure resulted in prompt return to normal. 162 pre-employment examinations were done. Site B shop was re-surveyed. Recommendations for increased ventilation were made because of the tuballoy dust hazard. Ingestion experiments with T_3O_8, TF_4, TCl_4, TO_2F_2, and TNO_3 are continuing. No abnormal findings have been found except a mild depression of weight in the TNO_3 and TO_2F_2 groups. Injection experiments with TNO_3 show that the 50% lethal dose is 10 to 20 milligrams per kilo. Dogs injected with 5 milligrams per kilo of TNO_3 have shown weight loss, weakness and an increase in the red blood cell protoporphyrin. Dogs who have been fed oxide for one year have shown no change. Dogs who have inhaled oxide of tuballoy once a week for 6 months have shown no change except the appearance of an unknown pigment in the urine. This is being studied. One human has been given 150 total r body radiation. The most marked change has been a fall in the lymphocytes from 1800 to 500 in the period of approximately one week. A temporary increase in urorosein excretion was also noted. Blood and urine pigment studies on Metallurgical personnel have begun. It is too early to report their findings. Dr. Barron has organized a group and is starting to study the effect of radiation on proteins.

B. Meteorological Section

Because the main stacks at Site W have not been completed, an auxiliary stack is being constructed to determine what conditions may be expected during the winter, the season of maximum intensity, duration and frequency of inversion. Meteorological observations of the various elements continue to be taken and a supplementary forecasting division has been established. Improved meteorographs have been completed.

C. Biological Research

The histological work with rabbits shows a marked damage to lymphatic tissue in the appendix within a few hours after an 800 r x-ray exposure. The cytological damage in the duodenum appears somewhat later. Experiments with Sr^{89} indicate that mice and goldfish can survive rather large bone irradiation as compared with the whole body radiation by x-ray or injected Na^{24}. Goldfish have been found to accumulate Sr^{89} to about 100 times the concentration of the medium in a week.

D. Radiation Measurement Section

A laboratory technician was added to the group to help with expanding routine radiation measurements. Measurements of contamination on hands have been started. Studies of the relative amounts of the biological dose contributed by gammas and by betas from UX indicate that gammas contribute approximately 0.1% of the dose when absorption in the intervening medium is small. Indications are that neutron survey meters will be available soon.

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A. CLINICAL MEDICINE AND CLINICAL RESEARCH

C. J. Watson, M.D., Associate Director and Section Chief

L. O. Jacobson, M.D., Acting Section Chief

Report for the month ending December 18, 1943

Liaison Committee Meetings - J. J. Nickson

As was announced last month, a committee known as the Liaison Committee has been formed within the Health Division with representatives from the Radiation Measurement Group, the Clinical Medicine Group and the Laboratory Medicine Group. Meetings were held weekly, at which meetings the following matters were discussed: First, individuals showing abnormal laboratory findings during the previous week. Second, individuals whose pocket chambers or film meters showed above tolerance exposures and, Third groups or areas where abnormal hazards exist. It should be understood that all cases of abnormal exposure or abnormal laboratory findings are not held for a week before being discussed, but are reported immediately to the appropriate physician and action taken when needed.

During the month 33 special surveys were made and reported to the Committee. In 15 of these the survey was made because individuals in the areas had had undue exposure to radiation or toxic materials. In no instance was over-exposure discovered at the time of the survey. Abnormal laboratory findings were sufficiently severe in 7 individuals to justify referring the individuals to the clinics of the Billings Hospital for further study. The cause of the abnormal findings was not definitely connected with their exposure but was sufficiently in doubt to justify further investigation.

Dr. Pardue has presented a list of individuals whose badge or chamber readings indicated a total exposure greater than .4 r for the previous week. The number of individuals has varied greatly from week to week. The variation in the main can be correlated with activities in Dr. Seaborg's section. During those weeks in which samples from St. Louis or Berkeley were being worked up the majority of the individuals concerned received more than .6 r during the week.

Mr. Cunningham's group in particular has been working during the past month with especially active material. Blood counts have been done frequently on the 14 individuals of this group; two of these had hematological alterations; one had a moderate reduction in platelets, which was thought not to be due to this exposure because of previous clinical laboratory data; the other had both a reduction in platelets and a reduced leucocyte count (below 5000) which was thought to be directly due to the radiation he had received. He was removed from further exposure for one week with a prompt return to normal in these blood constituents. Such individuals and appropriate controls are studied by Dr. [illegible] Schwartz and his co-workers for possible abnormalities in pigment metabolism and altered liver function. The report of his findings will be found in his section of the report.

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Hematology - L. C. Jacobson

The following table represents the hematological work of the past thirty days ending December 20, 1943:

Laboratory Procedure	Number Done	Percentage Abnormality
Hemoglobin Red Count	500	12
White Count	737	3
Differentials	737	16
Platelets	100	5
Urinalysis	630	7½
Reticulocytes	10	0
Blood for Wassermann	200	0.1
Sedimentation Rates	50	-

The number of abnormalities represents approximately an equal number of individuals on the "control" and "work hazard" groups. It is to be emphasized that less than 0.1% of the abnormalities above are thought to be due to work hazard. The resume of the month's work in the Clinical Laboratory is presented to emphasize the need for a continuous and comprehensive laboratory survey and particularly a parallel study of the control and work hazard groups. Such a report as the above will be submitted monthly with a breakdown of the abnormalities into control and work hazard groups. The latter will be further broken down to indicate whether the abnormality is definitely, presumptively, or not related to the work hazard.

Pre-employment Examinations - J. J. Lickson

162 pre-employment examinations were done during the above period. Of these, 40 were on academic personnel, 113 on non-academic personnel. One person was rejected on the basis of the physical examination.

Metallurgical Laboratory Hazards - J. J. Lickson

On 11-12-43 the Site B shop was re-surveyed for possible tuballoy dust hazard. As a result, recommendations for increased ventilation were made to Mr. Chipman and Captain Ware.

On 12-15-43 a letter was sent to Mr. Kimpton recommending that certain groups be provided with laboratory coats or coveralls. It is to be emphasized that our recommendations apply only to those groups who are exposed to special materials. Groups needing such clothing for other reasons were not considered, inasmuch as their needs for such clothing would not be on the basis of protection from radio-active materials.

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The development work on the use of a Geiger-Muller counter for measuring hand contamination has been continued by Dr. Pardue's group. It is planned to have measurements on a routine basis within the month. A part of the laboratory now being installed in New Chem for the Health Group will be used for this purpose.

The Cyclotron Chem laboratory has been and will be used for the crystallization and ether extraction of UNH. The equipment is inadequate for the job, both from the standpoint of ether fumes and from that of radiation protection. It was thought that the process was shortly to be moved into the West Stands into more adequate quarters. During the month it was learned that such was not the case. In consequence, Mr. Pyle and our group have requested certain alterations in the equipment to make the operation less hazardous from the ether hazard standpoint. The radiation protection measures must also be improved.

Industrial Surveys - J. J. Nickson

On 12-1-43 an industrial plant concerned with the preparation of metal was visited at the request of Mr. Greninger. In general the amounts of tuballoy dust in the air were in excess of the tolerance figure of .15 mgs. per cubic meter of air. Recommendations for increased ventilation were made.

The Effect of Radiation on Proteins - E. S. Guzman Barron, John Muntz

The published literature on the effect of radiations on proteins, although scanty and fragmentary, show that proteins are markedly affected, not only in their physical properties but in their chemical properties as well. If protein alterations appear early under the action of radiation it might be possible, by detecting those altered proteins to find the early phases of the toxic effects of radiations. It is essential therefore to study at the same time the effect of radiations on proteins in vitro and the effect of radiations on the blood proteins of individuals subjected to the action of radiations. For this purpose, the Tiselius apparentus of our laboratory is being mounted in a special room devoted exclusively to this work. A low temperature room is also going to be built for the preparation and preservation of these proteins. Electrophoretic analysis of the proteins will be accompanied with chemical analysis of the different reacting groups of the molecule -SH, NH_2, OH. We intend also to follow changes in the absorption spectrum and other physical properties.

A. Toxicity of Subcutaneously Injected Tubanyl Nitrate - A. Tannenbaum, H. Silverstone

The following experiment was designed to determine the toxicity levels of tubanyl nitrate when injected subcutaneously to mice, and to serve as a pilot experiment for work with other T compounds. Six comparable groups of white mice (the strain, average weight 29 grams; four months of age) were respectively injected with 8, 2, 1, 0.5, 0.1, or 0 mg. of T in the form of tubanyl nitrate in 0.5 cc. of physiological saline. The mice had free access to food and water.

About 24 hours after injection all of the mice appeared normal except those that received the highest (8 mg.) dose. These had ruffled furs and were relatively inactive. In the following days, mice of the groups that had received smaller amounts of T recovered and were minimal victims. Water intake decreased with increasing clinical symptoms and gradual loss of weight.

The following table gives the pertinent data and results:

Dosage-Mortality Relationship in Mice Receiving Subcutaneous Injections of Tubanyl Nitrate

Group Number	Dosate of T (mg) Per Mouse*	Dosate of T (mg) Per Kilo*	Number* of Deaths	Time of Death in Days after Injection
M101	8	280	10	2,3,4,4,5,5,5,5,5,6
M102	2	70	10	7,7,8,9,10,10,11,12,12,12
M103	1	35	6	8,8,9,13,13,16
M104	0.5	17	6	8,8,8,9,10,12
M105	0.1	3.5	0	
M106	0	0	0	

*Each group consisted of 10 male mice at an average weight of 29 grams (range of individual weights: 24 to 35 grams.)

In Figure 1 the weight curves of the surviving mice of each group are given. The curves for the mice of groups M101 and 102 are not shown, since all these mice died by the twelfth day. During this period these two groups lost weight at the same rate as M103.

It is to be noted that within the range of dosages injected the critical period is from the eighth day to the twelfth day. If the mice did not die by this time, recovery was the rule.

The toxicity of tubanyl nitrate is probable modified by various factors such as species, strain, sex and age. The 50% lethal dose, in this experiment with mice, was about 10-20 mg. per kilo body weight. This compares with McNider's value of more than 4 mg. for the dog and Hodge's value of 10 mg. for the rat. (intraperitoneal injection) These three values, all obtained with small numbers of animals are in good agreement and suggest that tubanyl compound affect these three species comparably.

B. Ingestion Experiments with T Compounds

The chronic ingestion experiments with TNO_3, TF_4, TO_2F_2, TCl_4 and T_3O_8 are continuing. The mice in these groups are receiving the following amounts of T per mouse per day:

TNO_3.....20.0 mg. T
TF_4.....100.0 mg. T
TO_2F_2.....9.3 mg. T
TCl_4.....20.0 mg. T
T_3O_8.....100.0 mg. T

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The experiments have been in progress for two months. The groups receiving U_3O_8, UF_4, and UCl_4 are growing at a normal rate and show no clinical evidence of toxicity. A few deaths occurred early in the groups given UNO_3 and UO_2F_2 but none since then. The weight levels of these two groups are somewhat depressed. Experiments were initiated to test whether the depression in growth rate that occurred in the UNO_3 groups was due to the "nitrate ion." Such experiments, using sodium nitrate, indicate that the "nitrate ion" was not the responsible factor.

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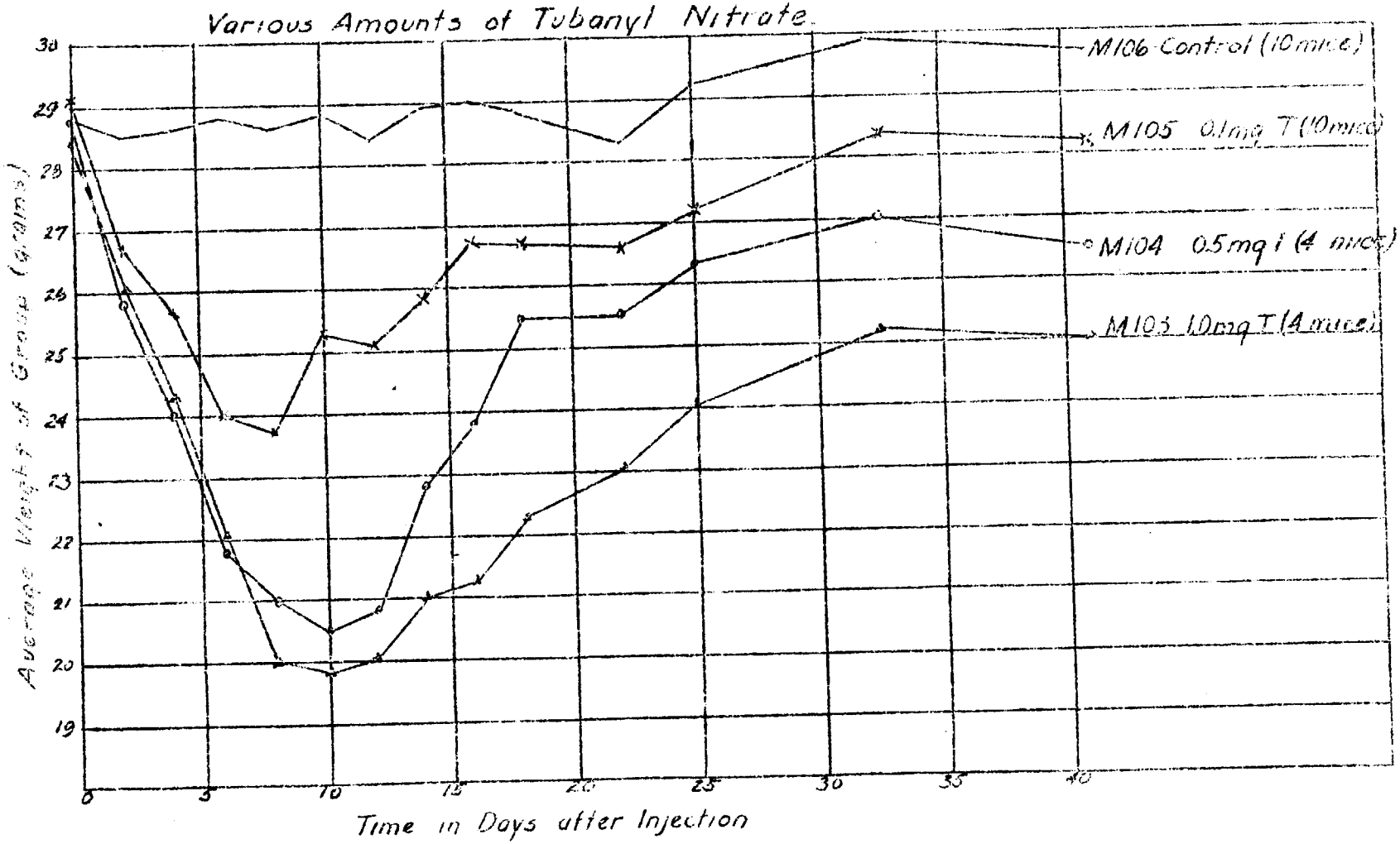
FIG. I Mean Weight Curves of Mice Surviving Subcutaneous Injections of Various Amounts of Tubanyl Nitrate.



Pigment and Liver Function Study Group - S. Schwartz (Report for month ending 12-20- 43)

Blood and urine chemistry studies which aim at the discovery or development of new tests to detect incipient damage due to radiation and metal are continuing on both animal and human subjects. Since adequate normal control data on several of these tests is not yet available, however, interpretation of data is still difficult. The fluorophotometer used for quantitating urine coproporphyrin has only recently become available and studies of this test now in progress are still insufficient to report. Other tests which we have been doing only recently and are not fully included in the scope of this report are protein studies (formal gel, colloidal gold, cephalin-cholesterol, and prothrombin time) and urine sulfate determinations.

The following results indicate the trend of our studies to date:
I. Animal studies.

A. Two dogs have received subcutaneous injections of TNO_3. Dog #1 received 5 mg/kg (total 53 mg.) subcutaneously on 11-25-43. He died 15 days later of distemper, complicated by pneumonia.

Significant changes were: 1) a rise in red blood cell protoporphyrin values from an average control level of 31.6 micrograms per 100 cc. cells (5 biweekly determinations), to 41.3 micrograms per 100 cc. cells (5 biweekly determinations). 2) A weight loss from 10.6 to 7.2 kg. was noted. Weakness was moderate, and the dog tended to walk with his chest on the ground.

Studies which showed no significant change during the course of the experiment included routine blood and urine analysis, urine urobilinogen, and urine uroroseain. Increased albuminuria and glycosuria, reported by several authors, was not found.

Dog #2 received 4 mg./kg. TNO_3 subcutaneously on 11-25-43. None of the tests performed have shown any significant change. He too has lost almost 3 kg. weight.

B. Three dogs exposed to dust inhalation weekly from Dec. 1942 to June 1943 were studied as were the injected dogs. The significant finding in these animals was the excretion in all three of a dark brown urine. The pigment has the color and spectroscopic absorption of bilirubin, and like it, gives a positive diazo reaction. Unlike bilirubin, however, it gives no color with either Fouchet's or Gmelin's reagent. The identity and significance of this pigment is being studied further.

It should be noted that one dog which received talcum dust insufflation as a control also excretes a dark brown urine. Since the same tube was used for him as for the other animals, however, (though rinsed with water before using) the possibility cannot be excluded that he too received some metal.

No glycosuria was noted in any of these dogs. Urine urobilinogen and albumin tended to be somewhat increased and blood protoporphyrin in one dog was moderately elevated. The total WBC in three was decreased with no change in differential. In the absence of data preceding the dust insufflation, however, these findings are impossible to evaluate. Since these dogs

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have been free from exposure for six months, insufflation studies on new animals are planned.

C. A group of three rabbits is being studied for the effects of UNO_3 injection. Data is still insufficient to report at the present time.

D. A group of three dogs who have been fed about 2 to 3.5 grams of T-oxide per week for about one year have been studied. One had a somewhat elevated blood protoporphyrin level, but again, no control data on this animal is available. In general, these animals appear to be in excellent health.

II. Human studies.

A. Radiation

1. A 67 year old male with a carcinoma of the right thumb and probable metastases received 75 r on 11-26 and 75 r on 11-27- 43, a total of 150 r, total body radiation. The fall in lymphocytes from about 1800 to 500 per cu. mm. constituted the chief change observed. The total WBC count has fallen from about 6500 to 3000.

The cephalin-cholesterol test which had been strongly positive before and shortly after exposure became negative two weeks after treatment. Total urine sulfur concentration fell from about 70 mg. per cent to less than 20 mg. per cent within three weeks after treatment.

On 12-16, 17 and 18 he received further daily doses of 50 r total body radiation. Complete results of this series of treatments are not yet available. It might be noted however, that within 4 days his uric acid excretion has increased about 60-70% and his urine urobilinogen and blood cephalin-cholesterol have become more strongly positive.

2. Blood studies on two workers on the project receiving relatively large exposures to radiation showed in one an elevated red blood cell protoporphyrin level of 52.9 micrograms per cent. (Normal value about 20-30 micrograms percent) This worker has a long history of radiation exposure, and tends to have a PMN/lymphocyte reversal.

B. Metal

Blood studies on four workers at Site F exposed to increased amounts of dust showed the following abnormalities:

1. Three had 1-4 plus cephalin cholesterol test
2. One had an increased blood viscosity as measured by the formol gel test.
3. Three had a lymphocyte percentage of 43 or more.

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B. METEOROLOGY SECTION

P. E. Church, Section Chief

At the University:- P. E. Church and R. H. Bentley

During the month of December plans were formulated and completed for the design of an auxiliary stack and entrance duct to be erected up one of the main stacks in the 200 W area at Site W. Design is such that not only can the smoke of a smoke generator be sent up the stack, but also some other gas, the amount of which can be easily determined when sampled at some distance downwind. Samples of air and the gas will then be taken laterally and vertically across the smoke trail to determine the degree of dilution and spreading (both lateral and vertical) under different wind velocities and lapse rates.

An improved low altitute meteorograph has been completed and its calibration is in progress. This type instrument will also be used at Site X.

An outline of the program of work to be performed by the Meteorology Section has been requested by several on the Project. This plan has been written and is submitted as an appendix to this report.

At Site W:--H. Winsor, C. Cosline, F. Mattingly & O. Newton

When weather permitted, the smoke generators have been operated, both singly and in pairs, and observations of the profile of the smoke trails and its flow pattern over the area in relation to the lapse rate have been made at both the ground and from an airplane. Continuous observations of temperature, relative humidity, and wind velocity are still being made at the base station. The daily record of the river temperature also continues.

When time permits, ascents by slowly rising free ballons have been made.

A forecasting division has been set up which requires most of the time of one man.

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APPENDIX

Outline of Meteorological work to be accomplished at Site W

The function of the Meteorology Section of the Health Division is to determine qualitatively and quantitatively certain atmospheric elements which will effect the flow and dilution of certain gases from the stacks of manufacturing units at two different sites. At present only one area, Site W, is being subjected to intensive study because the discharge of toxic gases at Site X is small enough to be considered non-injurious to life.

The most important meteorological and climatological elements which effect the flow and dilution of discharged gases which, of necessity, must be studied at the site involved may be outlined as follows:

I. Climatological

A. Wind---annual, seasonal, monthly
   1. Direction
   2. Velocities (from various directions)
   3. Calms (number)
   4. Duration of calms

B. Temperature---annual, seasonal, monthly

   1. Diurnal range
   2. Extremes

C. Precipitation---annual, seasonal, monthly

   1. Amount
   2. Snowfall
      a. Amount
      b. Duration

D. Fog---annual, seasonal, monthly

   1. Type and frequency
   2. Duration of each type

E. Daily or continuous record of river temperatures

II. Meteorological---limited largely to the lower 2500 ft.

A. Temperatures

   1. Diurnal variation of the lapse rate under different sky conditions at all times of the year to determine nocturnal and ground inversions--under calm, low velocity (1 to 3 mps), and moderate (4 to 8 mps) surface wind

      a. Rate of growth and decay
      b. Maximum height of the lid
      c. Degree of stability or amount of turbulence within inversion
      d. Amount of turbulence above inversion lid.
      e. Time of day and duration of adiabatic lapse rate

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2. Continuous records of air temperature at different locations within the site
3. Annual variation of lapse rates under different sky conditions and wind velocities.

B. Wind

1. Pattern of surface wind directions at different locations within the site in relation to different directions and velocities of gradient wind.

2. Vertical gradient of wind velocity especially during calm and low velocity surface winds, in relation to lapse rate.

3. Amount of turbulence with differing vertical gradients of wind velocity.

4. Continuous records of wind velocity and direction at a definite level at different locations within the site.

5. Frequency and duration of calms and low velocity wind at different locations within the site.

6. Drainage (cold air) pattern of the site under calm and low velocity winds.

C. Humidity

1. Continuous records at different localities within the site
2. Vertical humidity gradient concommitantly with vertical temperature gradient.

D. Subsidence inversions

1. Frequency of occurrence
2. Duration
3. Height of lid

E. Frontal inversions

1. Frequency of occurrence
2. Duration
3. Height of lid

Of the climatological elements (I, A, B, C, D in above outline) there are in existence some records from Pasco I. A_1, A_2, A_3 and I A_4 has already been computed and reported for the years 1951-1954 for the surface and two higher levels. The data for I B, C and D have not been digested as yet because these elements are not as important as others. Cooperative observers of the U. S. Weather Bureau have maintained fairly consistent records at Walla Walla and Touchet within site W for a number of years prior to 1945. In due time such data as can be used from those records which are pertinent to the atmospheric circulation of the site will be digested and reported.

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By reason of the plant growth in the river, which may have some effect on operations, and because no known observations on daily temperatures exist prior to the acquisition of the site, it has been requested that this unit record the daily temperatures of the river. This work was started in the summer of 1943 and is continuing.

Meteorological observations such as are required by the Project and which in the main concern the lower 8500 ft. are lacking for Site W except for certain wind observations taken at Pasco 1931-1934. Even prior to the acquisition of the site, it was realized that certain investigations must be carried on out in the field. The elements over which the Project is particularly concerned are listed in II A, B, C, D & E.

Though frontal inversions II, E will be relatively frequent in winter, they are short in duration (a matter of a few hours at most) are a high altitude phenomenon (above the zone which may prove critical), and are attended by relatively high wind velocities and turbulence.

Subsidence inversions, I, D, result from sinking of high altitude air by spreading flow of surface layers. The vertical motion downward operates toward a more stable lapse rate and with continued descent may produce an inversion. Stagnation of flow of air masses in the Great Basin is fairly common in winter with only one major sea level outlet, the Columbia River Gorge to drain the Great Basin. It is, therefore, quite possible that subsidence inversions can develop over Site W. The altitude and the degree of stability of such inversions is dependent on the length of time an air mass remains in the Great Basin. It is possible, though not likely, that a subsidence inversion may descend to the level which may be critical for the dissemination of toxic gases. This type of inversion needs to be investigated more thoroughly..

The flow and dilution of toxic gases issuing from a stack is dependent mainly on wind velocity and velocity gradient (velocity change with altitude change) and the stability of the atmosphere (vertical temperature change with altitude change). Because there will be certain areas where there will be a fairly large number of people living which could be affected by the toxic gases, the direction of the wind from the operation becomes important and must be observed especially in relation to upper wind direction and velocity. The wind velocity gradient along the vertical can be measured by slowly rising free balloons whose angles are measured simultaneously by two theodolites with a known base line between the instruments. Another method is to measure the angle from the vertical of a captive balloon. Both these methods are being employed on the site. Still another method is by fixed anemometers, but that requires a mast higher than is economically feasible to consturct..

From simultaneous observations at various places over the site it is possible to get a fairly accurate picture of the surface flow pattern of the wind.

The wind velocity gradient in the vertical which will give a fairly close measure of the degree or intensity of turbulence is intimately associated with the lapse rate, surface topography and mixing length.. The turbulence is therefore dependent on the stability of the air.. The degree of stability can be represented by $\frac{\Delta \theta}{\theta \, \Delta z}$ where θ is the potential temperature and z is

altitude. When $\frac{\partial \theta}{\partial z} = 0$ the atmosphere is in neutral equilibrium and any addition of heat at the bottom of the layer will cause free ascension and thus great vertical dilution. The above hold quite true with low wind velocities. When θ increases with altitude vertical motion of the air is retarded and any turbulence is dependent on the shear between air layers. With increasing stability comes laminar flow and any discharge from a stack will be maintained at constant level within the stable layer and lateral spreading will take place.

An inversion is a layer in which T increases with height. Most common are those which are formed by contact with a cold surface, either from snow or ice or from nocturnal cooling of the ground. The latter are far more common because the temperature of the ground at night, T_g, is lower than that of the air, T_a. The altitude to which ground cooling is effective is dependent on the $T_a - T_g$ difference, on the state of sky (amount and thickness of clouds, smoke, etc), the vapor pressure of the air, the wind velocity gradient within the layer, the length of time during which there is a net loss of heat from the ground, and amount of evaporation from the soil.

The frequency of occurrence, the stability, the wind velocity gradient, the height, rapidity of formation and decay of the nocturnal and ground inversions is, therefore, of paramount importance for the site for all seasons. It has been theoretically computed that the effect of radiation alone will build an inversion 100 meters thick in 11 hours. This does not include any further heightening of the top of "lid" of the inversion by turbulence or other factors. It is necessary to point out here that time during which radiation alone will be active toward producing and maintaining an inversion in winter at Site W will be considerably longer than 11 hours; perhaps 20 hours.

The technique of determining how rapidly an inversion forms, its maximum height, and rate of decay can be determined by serial ascents of a meteorograph (an instrument which measures temperature, and relative humidity against pressure) on a captive balloon. The Meteorology Section has developed a meteorograph designed for the specific layer in question.

The behavior of gases with regard to the dilution, horizontal spreading and vertical mixing by wind from any direction, with any vertical velocity gradient and under all degrees of stability can be determined by smoke or fog sent up a stack at the point where toxic gases will be emitted. A fog of oil particles is particularly long enduring; hence generators of that type have been procured and put in operation. The dilution can be detected analytically by putting up the stack at a known rate some gas, such as SO_2 which is easily detectable at low concentrations. Sampling must then be made at various places within the smoke trail to determine the concentration, or dilution, which may be expected under any atmospheric condition that develops.

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C. BIOLOGICAL RESEARCH SECTION

K. S. Cole, Section Chief

I. External Radiation

A. Animal survival - C. W. Hagen

1. X-ray: Single doses

Additional data have been collected on rats and guinea pigs. Their survival curves will be completed in the near future. Three-week chicks have been irradiated for blood and histological study. Initial survival data have been obtained. Recent survival data on goldfish indicate a greater resistance than was found in previous experiments. It is possible that this is caused by inadequate temperature control.

X-ray: Paired doses

Rabbits

The question of the time and extent of recovery from radiation exposure has been raised repeatedly. Rabbits which survived single doses of 500, 600 and 700 r for over 100 days recovered to essentially normal blood pictures and weights. These were given a second irradiation of 800 r. Of sixteen animals, eight died in six days or less, one in 12 days and the rest have survived up to as much as 24 days. This indicates that within 100 days there is marked recovery from irradiation damage because 1300 - 1500 r given at one time would have killed all of the animals. Present indications are, however, that those which died did so much sooner than they would have in the absence of previous radiation.

Rats

Four lots of 10 rats each were given an initial dose of 400 r and 7 days later a second dose of 0, 500, 600 and 700 r respectively. Forty per cent of the animals receiving the single dose died and ninety percent of those receiving a second radiation died. Further experiments of this sort will be made when the normal survival curve for rats has been established.

X-Ray: Divided doses

Lots of ten rats each were given daily doses of 200, 150, 100, 50, 25 and 12.5 r. The results at present are as follows:

Daily dose	200 r	150 r	100 r	50 r	25 r	12.5 r
50% survival	11 d	10 d	16 d	44 d	44 d	44 d
50% dose	2000 r	1200 r	1400 r	1900 r	1000 r	500 r

Drosophila has a normal survival curve of the same type as that of mammals. These animals are readily available in large numbers and they have the added advantage of a short life span. Preliminary experiments are under way to determine the effect of a single dose and of repeated doses upon their death rate.

1118703

A. Neutrons: Single doses

Neutron exposures of rabbits are being continued.

B. Histology and Hematology - L. O. Jacobson & R. Murray

1 X-ray - Single dose (800 r) rabbits

a. Bone marrow: the following new observations have been made of changes in rabbit bone marrow following single doses of 800 r:

Erythrocytic formation is at least as hard hit as granulocytic formation. Damaged cells include many nearly mature erythroblasts, even occasional orthochromatic erythroblasts, and lobated granulocytes.

Attempts at repair begin early (within 8 hours) but do not result in normal cells of the granulocytic series and apparently almost no new erythroblasts develop until much later.

There is extensive transformation of apparently undamaged reticular cells to hemocytoblasts. These mostly result in bizzare granulocytes (which degenerate in the marrow) or in phagocytic cells. These results raise the following questions: (1) Is the potentiality of the reticular cell altered by the radiation, (2) is the stimulus for maturation different or (3) are these several types of reticular cells of determined potentialities, some of which are damaged while others are not?

b. Appendix

The connective tissue of the mucosa may be divided into 2 tissues on the basis of the reaction to x-ray, (1) the stroma of the villi and the (2) lymphatic tissue of the mucosa occupied primarily by lymphatic follicles.

After x-radiation there is an extreme amount of cellular necrosis in lymphocytes especially in the follicles. The follicles become filled with necrotic cells and active macrophages. The necrosis has been detected as early as one-half hour and is maximal at 16 hours but the neoformation of large and medium lymphocytes from the fixed cells has begun even during the height of necrosis. Later lymphocytes are produced homoplastically. Gradually new follicles, which are actively lymphocytopoietic, form between the old follicles and the villi. Except in isolated cases and quite sporadically the old follicles do not contribute to the active lymphocyte regeneration.

In the lamina propria of the villi there is less necrosis and much less lymphocytopoiesis. The fixed cells swell up; some develop into giant atypical hemocytoblasts and plasma cells. Follicles are never formed here. Because of the apparent difference in reaction to x-ray the freed cells of the lamina propria of the villi will be referred to as stroma cells, those of the follicular part as [illegible]

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[illegible] and some [illegible] [illegible] [illegible]

Experiment 3. Groups of ten mice each were injected with 1, 2, 4 and 8 mg of NA in Ringer on each of seven days prior to x-radiation at 700 r. A control group received injections of Ringer only. These were adult mice and there were no significant weight changes prior to irradiation. The survival curves for four groups, those receiving 0, 4, 2 and 1 mg. NA daily, are presented in figure 1. The curve for those receiving 8 mg. daily fell between the control and 4 mg. curves.

It is concluded from the preceding experiments that NA given prior to radiation prolongs survival. There appears to be an optimum amount of NA at about two mg/mouse day. Greater or less amounts are not so effective. Experiment 1 also indicates that NA after radiation is toxic. These results could be explained by assuming that NA is required for the synthesis of the essential coenzyme DPN and that radiation destroys the enzymes which synthesize DPN.

Experiment 4. A group of 15 mice was injected daily with two mg. NA in 0.1 ml Ringer. A second group of 15 was injected with 0.1 ml Ringer daily. Both groups received x-radiation of 50 r each day. A third group of ten mice received the injection of NA but were not x-rayed. Each group of mice was weighed daily. The weight and lethal data are given in figure 2. It is apparent that the Ringer-injected group began to lose weight after eight days of radiation. The first deaths in this group occurred on the 12th day (600 r). At about the 8th to 10th day the Ringer-injected mice appeared very sluggish and rough coated compared with those which received NA. The two groups which received NA, one rayed and the other not, maintained about the same average weight and appearance until the fifteenth day. Two from each group receiving NA died by 19 days while 13 of those receiving Ringer were dead.

2. Enzyme inactivation - E. S. Gusman Barron

The effects of x-radiation on two enzymes and one coenzyme have been tested. The activating protein of lactate oxidase ("lactic dehydrogenase") was prepared from beef heart. This and a preparation of DPN (coenzyme I) were irradiated in two dilutions with 400 r. Enzyme activity was then tested spectrophotometrically by following the rate of diphosphopyridine nucleotide reduction by lactate. Neither the enzyme nor the coenzyme showed any reduction in activity. A second enzyme, succinoxidase from pigeon breast muscle, was given 600 r. It was then studied manometrically with succinate as substrate and no reduction in activity as judged by oxygen uptake was observed.

In these experiments and in most of the papers in the literature dealing with enzyme inactivation efforts have not been made to determine the optimum enzyme concentration, i.e., the amount of enzyme just sufficient to produce about 90 per cent of the enzyme-substrate complex. Failure to consider this may give false negative results, especially if the enzyme concentration is far beyond the saturation point of the enzyme-substrate complex. Future experiments are planned in which attention will be paid to this requisite.

3. Tissue catalase inactivation. C. L. Prosser

Measurements of catalase activity of various organs before and after radiation are being continued. The reduction in catalase activity in spleen and intestine are sufficient that peroxide poisoning is possible. Details will be reported later.

1118706

II. Biological Effects of Radioactive Isotopes

A. Inhalation, Preparation and Exposures - R. Abrams.

Xenon

Work this month on Xe has been concerned exclusively with the design and construction of a model Xe generator. The unit is practically complete and it is planned to place it in operation this month. The principle upon which the apparatus is based is that Xe will diffuse out of finely ground U_3O_8 at elevated temperatures. The U_3O_8 is to be placed in a quartz tube surrounded by a heater and insulator. The entire unit is to be placed inside the pile, and air pulled through continuously to remove the Xe as it diffuses out.

Since U_3O_8 tends to sinter at high temperatures a model experiment was carried out to check the possibility that such sintering would interfere with air flow. Apparatus was set up as shown diagramatically in Fig. 3. The U_3O_8 was packed in a quartz tube and N_2 was blown through the tube while the temperature remained at 1050° c. We used a column of 65 gm U_3O_8 23 cm. long and 1 cm. in diameter and passed N_2 through at 1.6 cc/min. This flow corresponded to four volumes per hour and so was 20 to 100 times larger than the flows to be used in the small Xe generator. The resistance to flow encountered in the apparatus was negligible at the beginning of the experiment (0.2 cm. of Hg) and decreased during operation to 0.1 cm. The decrease in resistance was a result of the fact that the U_3O_8 shrinks on sintering and pulls away from the walls. After 24 hours the flow was stopped, the charcoal heated to 300° C to elute the Xe, and the U_3O_8 dissolved in HNO_3 to recover any remaining Xe. The distribution of activity was as follows:

Remaining in the U_3O_8	1540 counts/sec.
Collected in Carbon Trap	6400 counts/sec.
Fraction of Total Activity Collected in Carbon	81%

Thus sintering does not interfere with air flow, and in all probability does not interfere with diffusion of Xe out into the gas phase.

Radio-Dust

It was reported last month that a dust of LaF_3 containing long lived fission products had an average life of 20 days in the lungs of a rat. The same experiment repeated with mice gave essentially the same results. The animals were exposed to an average dust level of 0.25 mg/l or 1.5×10^{-7} curies/l. There is a wide statistical scatter in the lung activities but the 20 day average life seems to fit satisfactorily.

Two new dusting devices have been constructed and are being tested.

Iodine

Development of techniques for isolation of carrier-free I^{131}

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and for ashing of tissues without loss of I is being continued.

Ruthenium

In the absence of any radio-isotopes of ruthenium, we intend to expose animals to inert RuO_4 in order to [illegible] of carrier that can be tolerated. A simple, sensitive test for Ru is required, and we have been attempting to put a qualitative spot test (after Feigl) on a quantitative basis. KI is mixed with $KClO_3$ and a small amount of starch. The oxidation of the iodide to iodine is catalyzed by Ru and Os. The rate of increase of the blue color of starch-iodine should be proportional to the concentration of ruthenium present.

We have preliminary results using an Evelyn photoelectric colorimeter to measure the blue color. As indicated in the following table the method is still only semi-quantitative but further refinements are possible and will be tried. When Log I_0/I is plotted against time a straight line of slope K^1 is obtained. The relation of K^1 to the concentration of Ru is given below:

Ru (grams)	K^1	$K = K^1 - K_o^1$	$\frac{K}{Ru}$
0	2.2×10^{-4}	0	-
0.1×10^{-6}	4.14	1.94×10^{-4}	1940
0.43	11.32	9.12	2120
1.12	28.9	26.7	2380
5.73	99.1	96.9	2040
		Av.	2120 ± 10%

B. Injection and Immersion

1. Strontium^{89}.

a. Preparation - R. D. Finkle

Sr. activity from S-18-HF was prepared by the Pb SO_4 method. In removing Ba by chromate, the Sr. became contaminated with the excess chemical chromate. Pb SO_4 was again found useful; the Sr activity was precipated without adsorption of chronium. The final product contained 6.6 mC with a specific activity of 1.5 mC/mgm of Sr (S-17-HF specific activity = 0.44)

Ba - Sr separations by means of chromate was unreliable in our hands. Also, chromium is almost as toxic as uranium and its removal is not always easy. Another disadvantage lies in the careful pH control with buffers necessary for Ba CrO_4 precipitation. This may represent a big problem for remote control operation. Lastly, a method which permits "back tracking" is highly favored in this work. We investigated the possibility of separating the chlorides in concentrated Hcl. The following values were obtained.

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Solubility

mgms/ml

	in 32% HCl 25° C	in 32% HCl 0° C	in 27% HCl plus 17% Ether 25° C	in 27% HCl plus 17% Ether 0° C	in Chromate Solution 15° C
Ba	0.07	0.05	0.01	0.008	0.002
Sr	2.2	1.6	0.83	0.67	0.4
Sr/Ba	31	32	83	84	200

The chloride method appears to be very promising and we expect too inventigate it further. The method using 27% HCl and 17% Ether has already been used on S-18-HF and on the recent preparation at Site X.

b. Mice. R. D. Finkle

The Sr-120 solution prepared from S-17-HF by the Pb SO_4 method last month had a specific activity of 0.44 mC/mgm Sr- total activity = 4.2 mC. The solution was made isotonic with NaCl and injected I.P. into white Bar Harbor Mice, 4 mice per group.

Group	μc/mouse	Date	Excreted in 24 hrs. %	Excreted in 7 days %	Total Recovery Excreta carcass %
I	.21	11/16/43	17	21) Poor Ashing Method	-
II	84	11/16/43	21	26)	-
III	167	12/1/43	26	47	101
IV	312	12/1/43	25	55	104

Distribution As the animals died or were sacrificed for histological study femurs (except 12/6 samples* which were radii and ulnae) were recovered, ashed and analysed. No other tissues were examined.

Group	Date	Days after injection	Wet Wgt. mgms.	Activity μC	Intensity r/day
I	11/22	6	24.5	0.24	274
I	12/6*	20	71.6	1.84	586
I	12/14	28	42.7	0.16	80
II	11/22	6	31.1	0.77	695
II	12/6*	20	63.2	1.34	445
II	12/14	28	47.4	0.70	316

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Group	Date	Days after injection	Wet Wgt. Mgms.	Activity μC	Intensity r/day
III	12/11	10	34.6	2.6	2270
III	12/14	13	38.6	2.4	1845
IV	12/11	10	33.3	4.7	4370
IV	12/11	10	35.4	4.8	4080
IV	12/12	11	36.7	4.8	3940
IV	12/13	12	41.8	4.3	3080

The intensities were calculated on the basis of the activity being uniformly dispensed in the entire bone as follows:

$I = 61\ EQ/W$, W being the wet weight of bone

The total radiations were calculated by deducting decay and excretion from the activities of the initial injections.

Group	Duration Days	Total Dose r	Whole body* r	Bone only** r
I	28	14,400/W	720	12,000
II	28	36,300/W	1810	30,200
III	125	36,300/W	1810	30,200
IV	12	52,200/W	2610	42,000

* Whole body dose = Total Dose with W assumed to be 20 gms.

** Bone only = " " " " " " " 6% of Body Weight

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It is evident that there is a continuous exchange of calcium between the fish and medium and that if calcium is low externally and strontium available this latter element will be taken. When the external calcium is replaced by inactive strontium (beaker 5) more active strontium is taken than in the same concentration of calcium but less than in low calcium. Hence there must be some selective uptake and preference for calcium over strontium.

When the results are expressed in total concentration or amount of active strontium accumulated the uptake depends similarly upon external calcium, but the total uptake is much greater with high Sr^{89} than with low Sr^{89} whereas the increase in concentration above the medium is in reverse order. This means that the total amount of radiation received by fish is greatest in high Sr^{89} in low calcium.

The total amount of radiation received internally over the two-week period was calculated. External radiation was not over 0.5 r/day in any beaker and therefore negligible. For tank 3 the goldfish received a total of 648 r in 14 days. They were receiving at the rate of 79.4 r per day on the 14th day. In tank 8 the fish were receiving at the rate of 35.2 r per day on the 10th day and 92.5 r per day on the 23rd day. Not enough fish were removed from this tank to calculate the total dose because they were left for survival. It is likely that those which survived 23 days received over 1200 r per gram. These fish died no faster than did the controls (beakers 6 and 7). It is concluded that the threshold for internal radiation by Sr^{89} must be higher than 1200 r over 23 days.

The Sr^{89} accumulates in different parts of the fish in decreasing amount in the following order: skin skelton soft parts. Typical results for fish from beaker 4 at 7 days follow:

	μC/gm	concentration
Skin	0.131	68x
Skeleton	0.076	40x
Soft Parts	0.036	19x

Separation of a fish from beaker 8 (high Sr^{89}, low Ca) at 23 days gave the following

Skin without scales	3.56	μC/gm	163x
Scales	27.26	"	1250x
Skeleton	4.116	"	189x
Soft parts	2.62	"	120x

The above figures on radiation are calculated for the fish as a whole. Actually the skin receives more, the internal organs and muscle less and the skeleton receives approximately the amount given.

Radioautographs of whole fish (fig. 5 a and b) clearly show very great concentration of Sr^{89} in skin and skeleton. The entire fish is outlined and the backbone skull and gill basket are well shown. Individual scales are very active (fig. 5 d, e and f, g). The high activity in scales is not due to adhering strontium as the fish were washed well before weighing and were passed through formalin and alcohols before radioautographs were made. Also the radioautographs show greatest blackening

Biological Effects

Group	mc/Kilo	Died from Radiation	Av. Wgt. changes (gms) 5 days	14 days	28 days
I	1.05	none in 28 days (3 sacrificed)	0.2	0.1	0.9
II	4.2	none in 28 days (3 sacrificed)	-5.0	-2.3	0.3
III	8.35	3 in 13 days (last mouse is very sick)	-1.8	-4.8	-
IV	15.6	4 in 12 days	-2.7	-10.3	-
Controls	None	None	0.3	1.1	2.3

Summary

In these experiments the most interesting results are those of Group III. These mice received tremendous doses of beta radiation without adverse effects; their bones received upward of 300 r for over 28 days. No conclusion or explanation will be attempted until these findings are confirmed in further experiments.

c. Goldfish. C. L. Prosser

Accumulation and localization of Sr^{89}

Three experiments, each lasting two to three weeks, have been performed during the past two months. These agree well and the results of the last and must complete experiment are presented here. Each of eight beakers as filled with 2 liters of synthetic pond water (see CH 1089 for formula) with the following variations:

Beaker	Inactive Ca or Sr	Sr^{89}
1	$CaCl_2$ 100 mg/l	10 μC/l
2	" " "	1.9 μC/l
3	" 5 "	9.0 "
4	" 5 "	1.3 "
5	$SrCl_2$ 100 "	12.0 "
6	$CaCl_2$ 100 "	0.0
7	$SrCl_2$ 100 "	0.0
8	$CaCl_2$ 5 "	59.5 μC/l

Five goldfish were placed in each solution. From the first five beakers fish and solution were removed at intervals and their activity measured. Some of the fish were dissected into skin, skeleton and remaining soft parts and each of these ashed and measured separately.

Results in terms of number of times the concentration in the medium are given in figure 4. This figure shows that Sr^{89} is accumulated very rapidly for about a week and then is accumulated more slowly. The accumulated very rapidly for about a week and then is accumulated more slowly. The accumulation is less in solutions high in calcium (1 and 2) than in solutions low in calcium (3 and 4). The percentage increase in concentration is greater with lower strontium concentrations (2 and 4) than with higher strontium in comparable calcium concentrations (1 and 3).

in bands (f) corresponding to dense closely-packed scale rings (g). This must mean that the calcium in the scales of fish is constantly exchanging for calcium (or strontium) in the medium. The radio-autographs of goldfish tails show regular dense spots along the rays (Fig. 5c). These correspond to joints between individual small bones. Either the rate of calcium metabolism is highest at the ends of the bones or else most of the radiation is from bone surfaces, hence the ends give a dense exposure.

2. Mice Injection. R. D. Finkle

Another set of experiments on mice injected with Na^{24} prepared by the Chicago Cyclotron are not yet complete. Therefore, the previous figure of 630 r for the probable lethal dose remains unmodified.

III Miscellaneous

A.G.M. tubes

One man spent two weeks full time making G.M. tubes. Three tubes are now on hand which have operated satisfactorily in every respect for two to four weeks, except for high backgrounds of three to five counts per second. Work on tubes was discontinued because of the pressure of other work. We have been able to function without daily use of our counting instruments because the electroscopes were calibrated with respect to Na and Sr. Good G.M. tubes are essential for the work next month and some time will have to be spent on them.

B. Radioactive isotope separation.

Ce activity was prepared from S-17-LaF_3 by repeated iodate precipitation with thorium carrier. The specific activity (ca 1/10 mC/mgm) is low and the material was set aside for "tracer" work.

Zr activity was prepared from S-17-HF after $PbSO_4$ precipitation. The solution was passed through a resin column to which the Zr activity adsorbed. No Sr activity was found in the filtrate or washings. The column with adsorbed activity was sent to Site X. After elution of the activity with HF the preparation will be used as a "tracer".

UX_1 activity from St. Louis residues (ca 0.1 mC/gm) received some attention this month. Test runs show that the activity can be concentrated as the oxalate or iodate using Cerium or Thorium carriers. The losses are too great to make these methods whrth while. If time permits, we would like to adsorb the activity on a resin column.

Br^{82} preparation was tested at the Chicago Cyclotron. A one pound bottle of brom-benzene was exposed to the neutron beam for about one hour. Extraction with water yielded 0.025 mC. Long runs at Chicago or St. Louis may be worthwhile.

C. UNH toxicity for goldfish

During the past month the UNH experiment reported previously was repeated using an improved procedure. UNH solutions were prepared in synthetic pond water in concentrations of 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}

10^{7}, 10^{8}, and 0 parts by weight of uranium. Seven fish were placed in two liters of each solution and each concentration was duplicated except the 10^{-8}. Solutions were changed every 4 - 5 days. Cotton filters were used during the first transfer, but were abandoned later since solutions remained clear for the four days between transfers without them. Considerable accumulation of UNH could be observed on either cotton or glass wool filters when these were used.

Results of the two UNH experiments are compared below. Data are of nineteen days after beginning of the experiment.

Concentration of Uranium	Solutions in Distilled Water No. of fish	No. dead	Solutions in Pond Water No. of fish	No. dead
10-3	14	14	14	14
10-4	14	14	14	14
10-5	14	14	14	4
10-6	14	5	14	0
10-7	14	6	14	0
10-8	7	3	7	0
0	13	5	14	1

The results indicate that Uranium is less toxic when other ions are present and that control survival is considerably better with the improved procedure.

D. Radio-autographs.

To determine the photographic negatives best suited for radio-autographic work ten different kinds of film have been exposed to a beta ray source for different lengths of time. The density of blackening of the film was measured with a densitometer (density = log $\frac{1}{\text{transmission}}$ whose transmission = $\frac{\text{transmitted illumination}}{\text{incident illumination}}$.

The accompanying curves (Fig. 6) were obtained by subjecting the indicated films to a series of exposures to uranium foil (.032 in.) covered with a sheet of paper. The paper covered uranium served as a beta source equivalent to .19 r per hour.

On comparing the curves it is evident that a great variation in sensitivity to beta radiation exists among the various emulsions. For example, Agfa non-screen requires a much shorter exposure to produce a given density than Dupont Industrial 509. Agfa non-screen is useful when the radiation being used is quite weak and exposures of 20 or 30 days are necessary. Dupont Industrial 509 is slow and is suited to strong radiation with exposures of one to five days.

The curves show A n-s to have a density range of about two while D I 509 has one of 2.8.

Density range is related to the ability of a film to record detail over the whole exposure region. The greater density range permits the recording of more detail. This factor as well as others such as graininess are important in selecting a film for a given purpose.

Removal of the emulsion from one surface of double coated X-ray film has been employed successfully. The exposed, developed, and fixed film was placed with the surface to be removed in contact with filter paper wet with Chlorox, care being taken to prevent the other surface from coming in contact with the solution. After the emulsion had dissolved the film was washed and dried. This procedure impoves contrast and is now being used entirely in all our radioautographs.

IV Plans for coming month.

The most important work for the coming month is that on Sr^{89} and Ba^{140} from X. The program for the complete section includes the use of the isotopes on mice, rats and goldfish for: metabolism, radio-toxicity, histological and haematological investigations.

The survival curves of rats, guinea pigs and chicks for single dose X-rays will be largely completed. Fast n exposures will be continued. The collection and correlations of weight changes following irradiation of rabbits, rats and mice will be brought up to date. The investigations of the effects of repeated doses of X-rays will be continued.

Histological survey of effects of 800 r and 400 r single dose X-ray for rabbits will be largely completed. Similar survey for rats and mice will be continued. Cytological study of chicks and newts after single dose of X-rays will continue.

Haematology studies at low leve single dose of X-ray and the blood picture after injection of radio-active isotopes will be emphasized.

Protective action of enzyme precursors will be studied. The effect of radiation on enzyme and protein solution will be continued. Tissue enzyme inactivation studies will be continued.

The Xe^{133} model generator should be tested at X and work on I, Ru and radio-dusts will continue.

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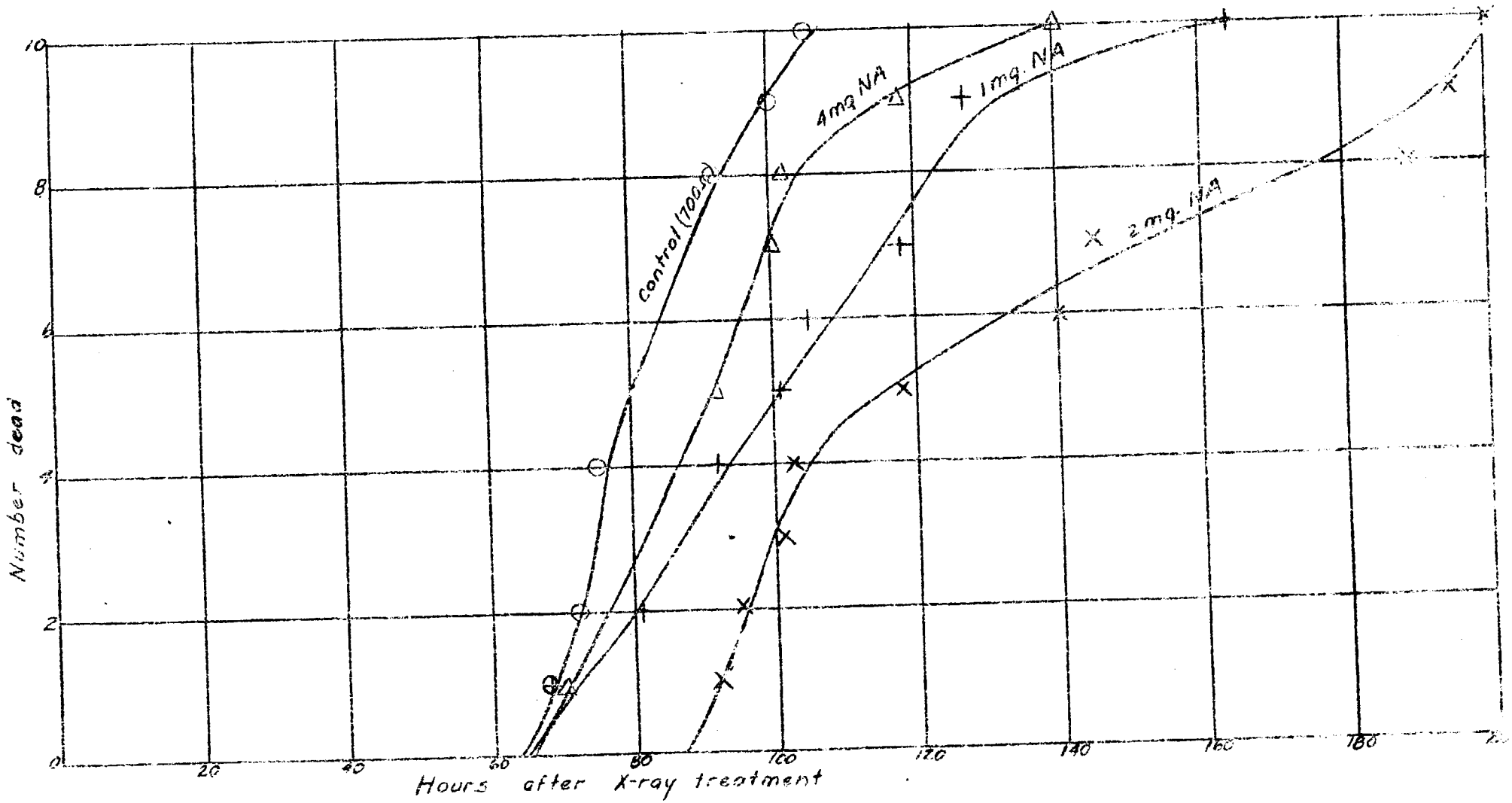

FIG I

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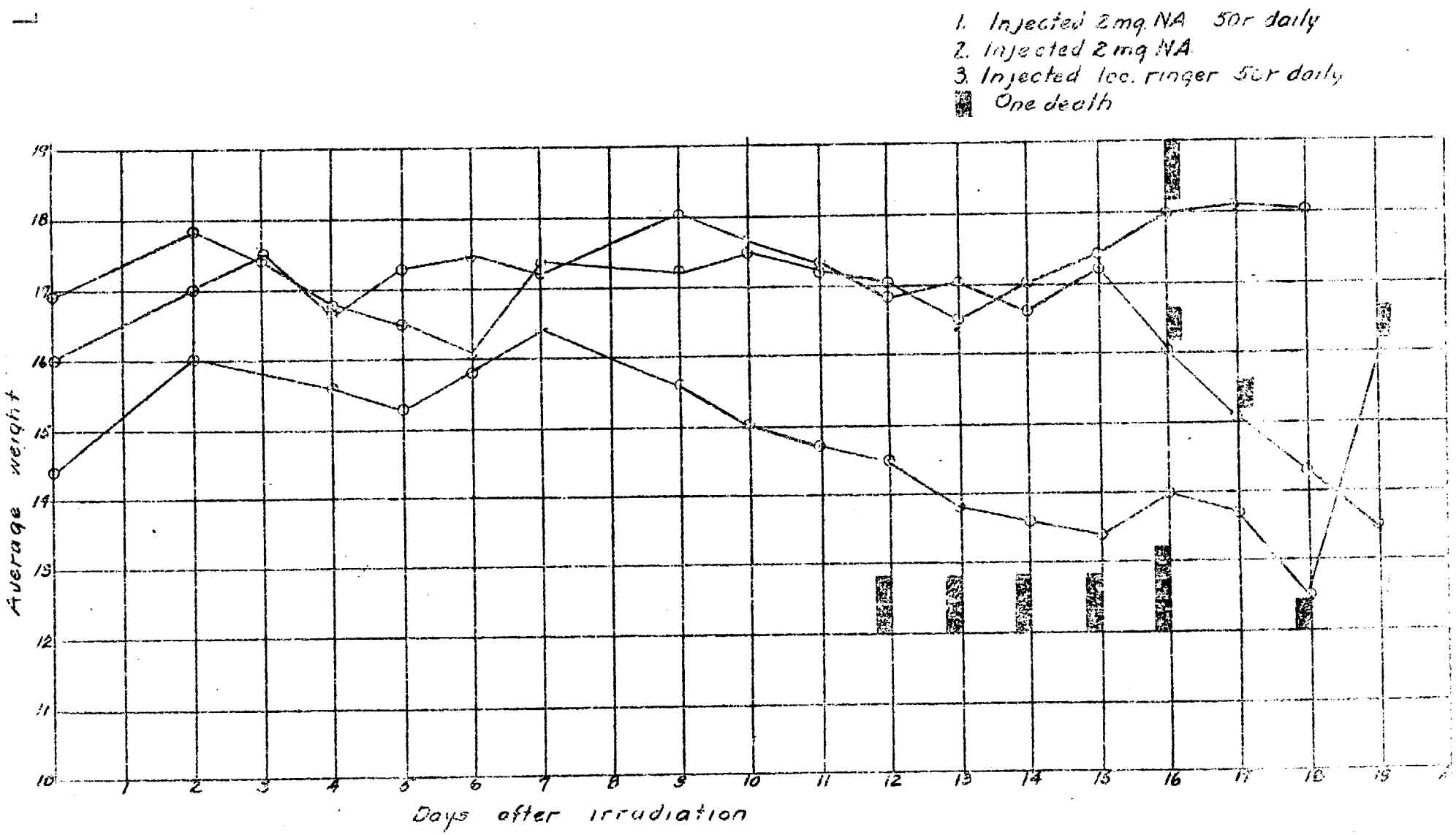
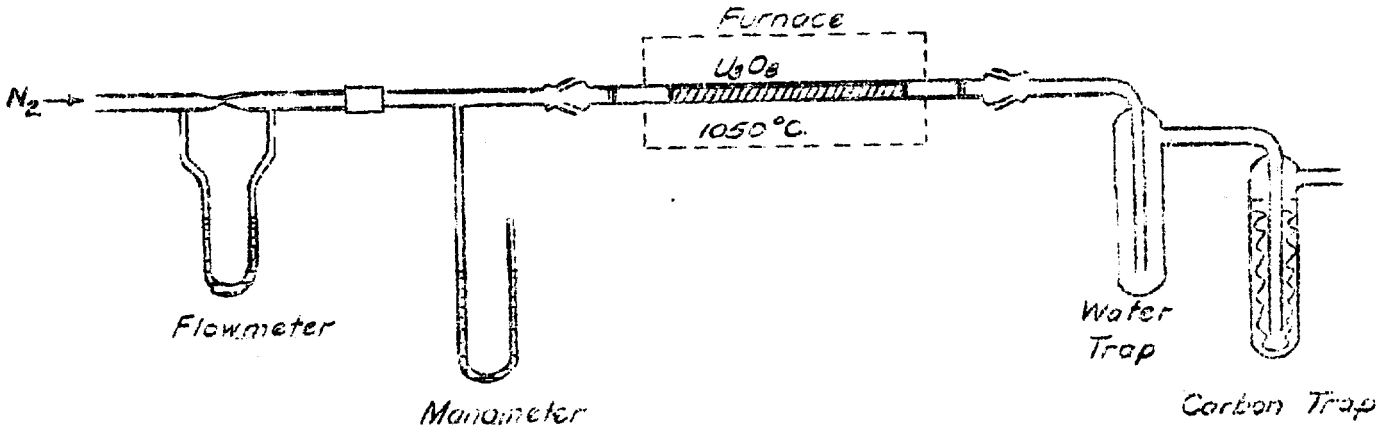


FIG. 2

FIG. 3



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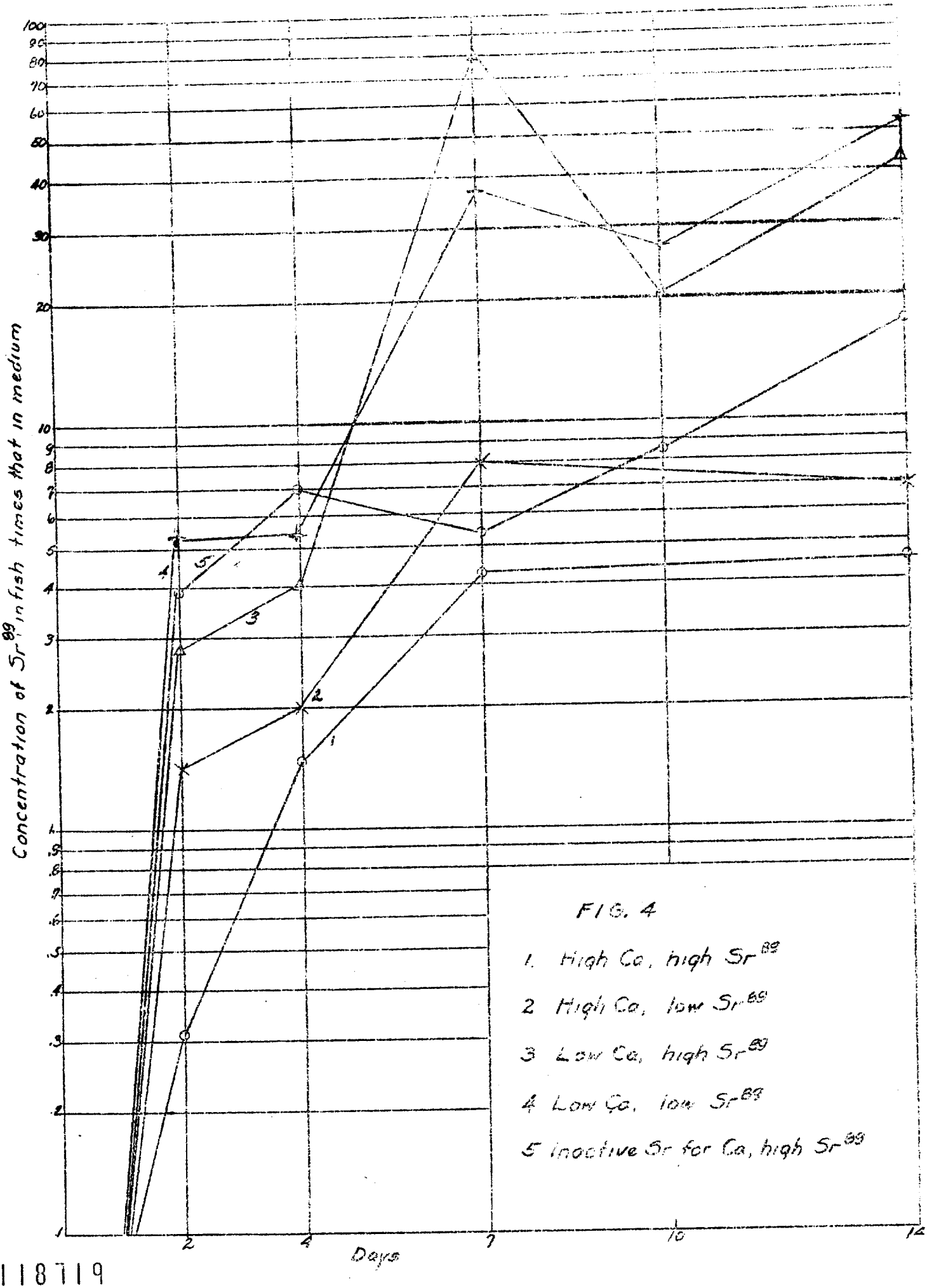
Concentration of Sr^{89} in fish times that in medium
Days
1
2
3
4
5
FIG. 4
1. High Ca, high Sr^{89}
2 High Ca, low Sr^{89}
3 Low Ca, high Sr^{89}
4 Low Ca, low Sr^{89}
5 Inactive Sr for Ca, high Sr^{89}

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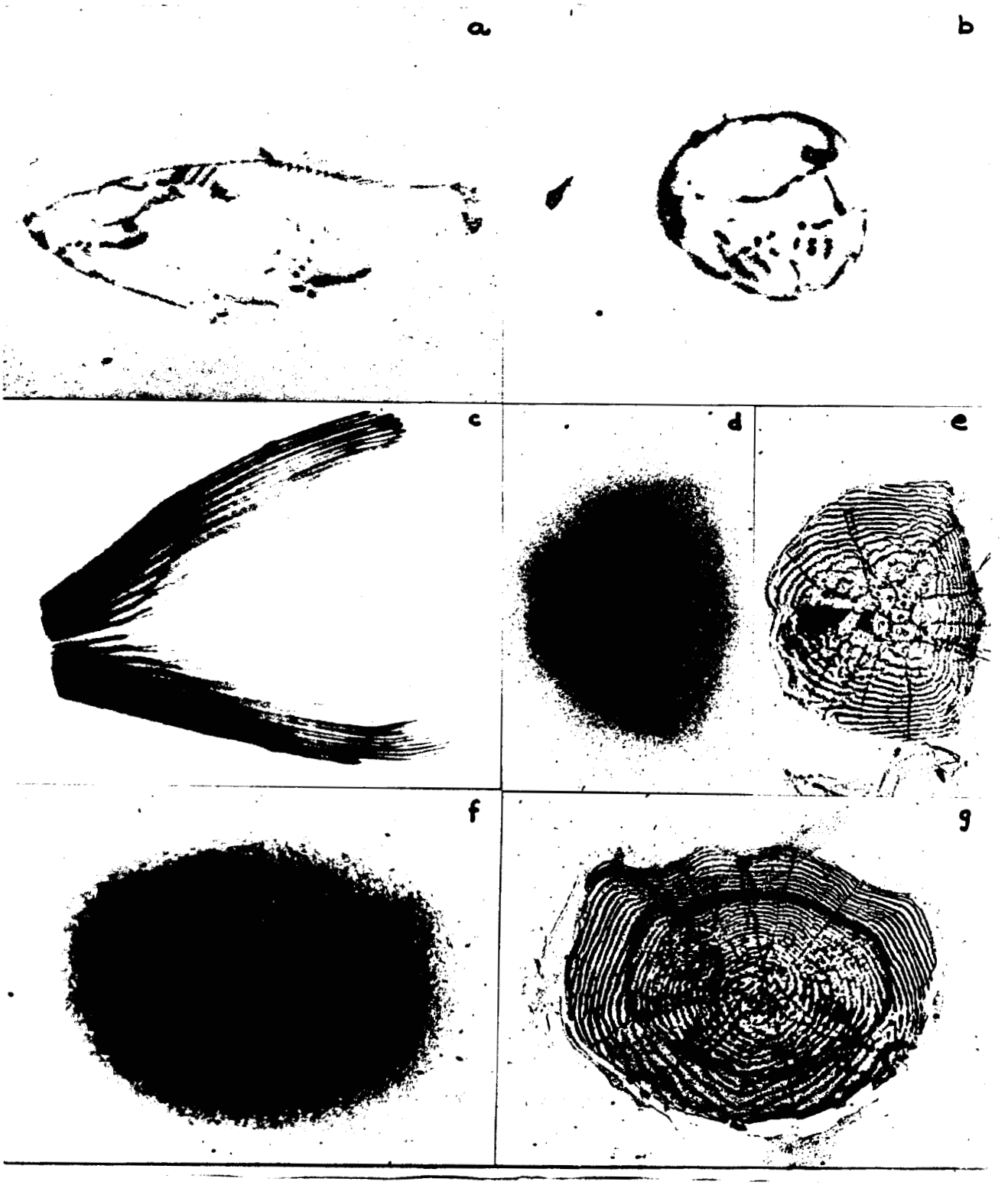

Figure 5. Radioautographs and scale photographs of fish
(a) Radioautograph of sagittal section of a platy.
(b) Cross section in gill region of guppy
(c) Tail of a goldfish
(d) Radioautograph and
(e) Photograph of a goldfish scale in which rings are uniform.
(f) Radioautograph and photograph of a scale with dense band of rings through the mid portion of the scale.

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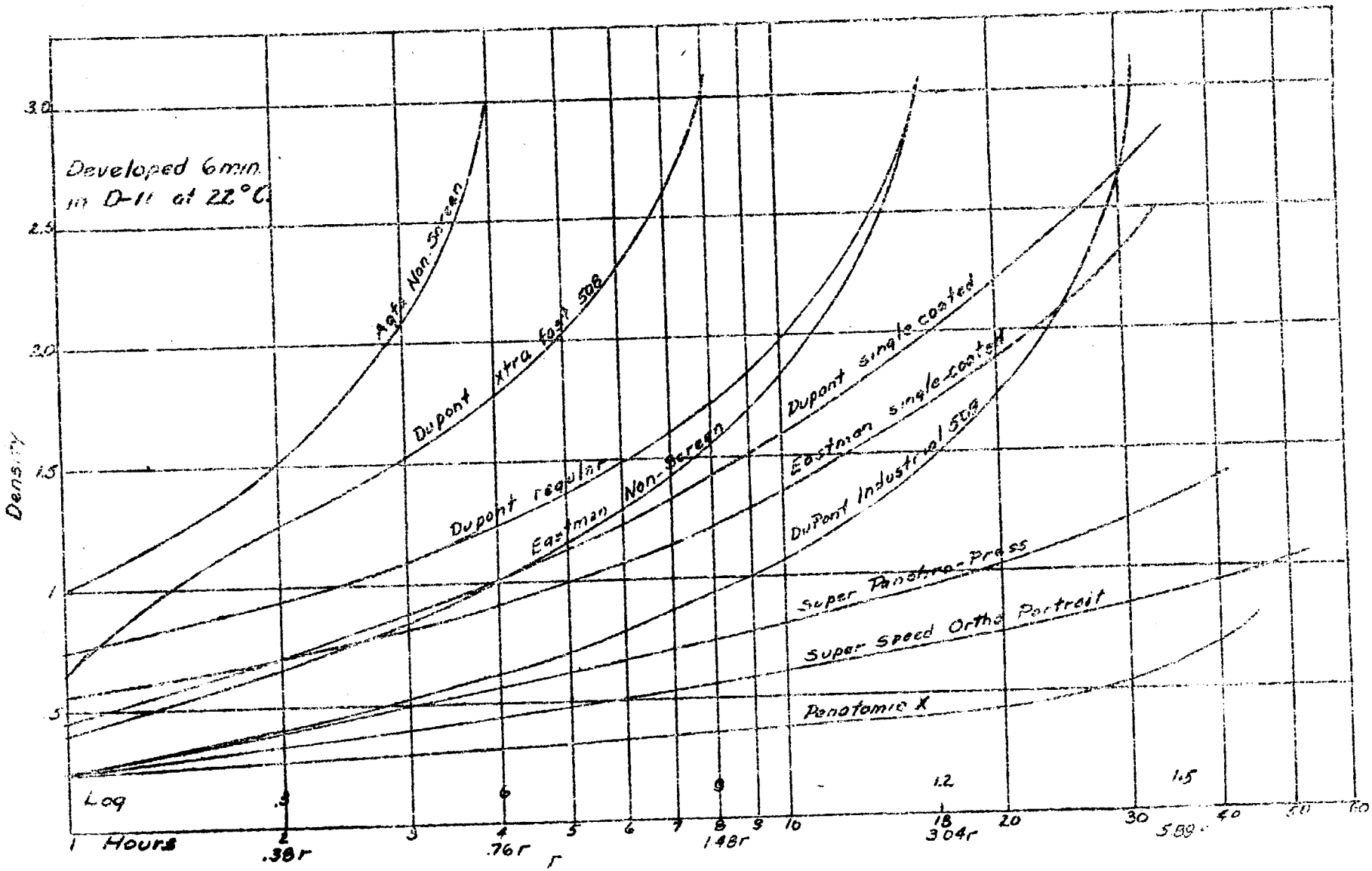
FIG. 6



D. RADIATION MEASUREMENT SECTION

E. O. Wollan, Acting Section Chief

Report by [illegible]

Mrs. Ellen Blattenberg joined the group on December 9. She will help with the expanding pocket chamber and film meter work. 141 pocket chambers recently received from the Victoreen Instrument Company are to be put in service as soon as they can be tested. Many more film meters, all of a new type, will be in use as soon as they have been received and assembled. It was expected that this would have been done this past month, but the latest estimate on the delivery of the new badges is January 1. Also, two new programs, one on hand counting, the other on finger printing, are being developed.

Little need be said about the pocket chamber program. It is now carried out routinely. They seem to give a reasonably reliable indication of general body radiation. A steady increase in the number worn regularly is noted but there remains room for improvement in this regard. The film meter program has continued unchanged except for the installation of a constant temperature developing tank. While the present film meters are not so accurate as the pocket chambers they do give more than a qualitative indication of the accumulated weekly exposure.

Of the two new programs for detecting radiation hazards, the one on hand counting has been begun in a preliminary way in the library at Ingleside. The present location is bad as it interferes with the normal use of the library. It appears this condition will be remedied shortly as the Health Division is to have a room in the New Chemistry Building. When this is available hand counting will become a standardized routine. In this work a thin walled counter is set up with a special compartment for inserting hands. It has been calibrated by determining the count a sheet of Uranium the size of a hand would give. Then one passes from counts to doses. A reasonable safety factor is allowed for the uncertainties of the calibration. A uniformly contaminated hand would give approximately 1600 ^{c}/min with our counter if it were receiving a tolerance exposure. 300^{c}/min will be considered bad. So far only one person has exceeded this minimum. Another use the counter can be put to is that of measuring the contamination on gloves. This has been done for four representative leather gloves from W used in handling heavy metal. The worst gloves gave an exposure to the hands of 2.5 mr/Hr. The gloves from Argonne are to be tested soon.

Studies of the St. Louis residue, rich in UX have been continued to determine the relative amounts of the biological dose contributed by gammas and by betas. It has been necessary to work with very thin sources to avoid beta absorption in the residue. This has made ionization measurement somewhat difficult. Obtaining a workable thin-walled counter was delayed. However, fairly good measurements have been made by both methods. They indicate that approximately 0.1% of the dose, when absorption of both in the intervening medium is negligible, is due to gammas. Incidentally, this means approximately 1 gamma to 20 betas emitted.

Neutron survey meters, of which there have been none, are beginning to emerge. Two are in the final stages of development and should be available for use in the near future. They are hydrogen filled ionization chambers differing in the way the ionization current is read. One developed in the Instrument Section employs a vacuum tube amplified. The other designed by Dr. Wollan,

makes use of an electroscope and is intended to mix gamma and neutron induced ionization in the proper ratio, so that the combined dose can be read directly. These meters should provide at least a good start. The first modification for improvement will probably be to line the walls with material of low atomic number to reduce the wall effect which may not be excessively large now unless the radiation has a large low energy component. A minor problem of design will have to be overcome since the chambers are to withstand a pressure of the order of 300 lbs/in^2.. Further work is being done on Dr. Wollan's design of thimble chambers of the Victoreen r-meter type made with conducting plastic walls. At present, tests are being made to see if different chambers made to the same specifications give concordant results in gamma and neutron exposure. Ultimately it is hoped to read neutron doses by using two chambers with different walls. If this is successful it will be important because the present methods of using a standard Victoreen chamber with gammas shielded off is open to question because of the unknown degree to which this is done. Also, it is not well known how concordant are the results obtained with different chambers.

Surveys, as usual have been made rather widely over the project. The Cyclotron remains one of the most critical places. Pocket chambers have been planted around it and will be read daily to determine the maximum exposure obtainable by workers there.. Radiation measurements are transmitted weekly to the clinical group.

Consideration is being given to the contaminated gas problem at Argonne.. Measurements are taken there regularly by Mr. Rylander using counter methods.. Evaluation of them is to be undertaken.

The following results were obtained on December 9. The pile had an output of 62.3 K.W.H. at the end of the day..

Position Where Sample Taken	Cts/min
Directly above the thermal column	too active
Just inside the room atop the pile	1800
Edge of the shielding of thermal column	4150
North face of the pile on testing platform	585
Atop pile, outside room about 12' from thermal column shielding	451

Work for Coming Month

1. Expansion of pocket chamber service
2. Assembling film meters
3. Surveys
4. Routine measurements
5. Calibration of Neutron Meters
6. UX measurements

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Supplement to CH-1162
(A-1645)

METALLURGICAL PROJECT

A. H. Compton - Project Director
R. S. Stone, M.D. - Associate Project Director for Health

* * *

METALLURGICAL LABORATORY

S. K. Allison - Laboratory Director

* * *

HEALTH DIVISION

R. S. Stone, M.D. - Director
C. J. Watson, M.D. - Associate Director

* * *

CALIFORNIA PROJECT

J. G. Hamilton - Project Director

* * *

NATIONAL CANCER INSTITUTE

R. R. Spencer, Chief

Supplement to Monthly Health Report for Month Ending December 25, 1943

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ABSTRACTS

I. H.O.I.

The blood picture of mice having received approximately 2250 r up to the present at the rate of 8 r per 8 hours per day is essentially the same as that reported last month. (Slight decrease in RBC, WBC and platelets). All other experimental animals exposed for the same length of time but at lower rates (4 r, 2 r, 1 r, and 0.1 r per 8 hours per day) show a similar blood picture as the controls.

The blood picture of guinea pigs (2 of 18 alive) having received approximately 2250 r up to the present show a slight decrease in total white count and a decrease in RBC and platelets. The blood picture of the guinea pigs on the 4 r per 8 hour level (16 or 18 alive) show a decrease in white count and a slight decrease in RBC. Two developed anemia during the month and were killed. The dose received by these two guinea pigs corresponds with the dose at which many of the guinea pigs of the 8 r per 8 hour level and were killed due to anemia. This indicates that as far as the hematopoietic system of the guinea pigs is concerned the dose is cumulative for the dose rates of 8 r per 8 hours and 4 r per 8 hours.

The blood picture of the rabbits is normal with the exception of the animals on the 8 r per 8 hour level which show a lowered WBC.

The breeding experiments gave the following results. Male mice exposed to 1600 r on the 8 r per 8 hour level show severe testicular damage and were sterile for approximately 8 weeks, after removal from the field. After this time 2 out of the 8 so far have successfully mated. Males exposed to lower doses on the same or different levels remained fertile.

Females mice exposed to 500 r on the 8 r per 8 hour and 4 r per 8 hour levels showed decreased litter size. Female mice, exposed to 800 r on the 8 r per 24 hour level showed considerably decreased litter size. Female mice exposed to 600 r and 500 r on the same level show normal litter size. Results of exposure to 500 r on the 8 r per 8 hour level and 8 r per 24 hour level may indicate that the dose is not wholly accumulative as far as the ovaries of mice is concerned.

Female mice exposed to an acute total body exposure of 300 r of X-rays (given in 7 min.) and mated immediately after exposure gave litter size only slightly lower than normal. All of these females had litters.

The histological observations in mice are as follows:

Total doses: 8 r per 8 hour group: 500 r in 2 months, 1000 r in 4 months, 1500 r in 6 months, 2000 r in 8 months..4 r per 8 hour group: 250 r in 2 months, 500 r in 4 months, 750 r in 6 months, 1000 r in 8 months.

Significant changes are observed only in the lymph nodes, gonads and adrenals.

Lymph node changes in both the 4 r per 8 hour and the 8 r per 8 hour groups consisted on the appearance of giant follicles at 2 months. Thereafter there

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[redacted] was no change other than a slight decrease of small lymphocytes in the germ follicles.

In the testes there was progressive atrophy of the tubular tissue. This was severe after 8 months in the 8 r per 8 hour animals although a few mature spermatozoa were seen in both animals of this group. This atrophy was less marked at 8 months in the 4 r per 8 hour animals than at 4 months in the 8 r per 8 hour ones.

In the ovaries there was progressive diminution in the number of follicles. Absence of follicles was first noted at 6 months in the 8 r per 8 hour mice and at 8 months in the 4 r per 8 hour mice. Thus this difference of degree of atrophy in the two groups for the ovaries was inverse to that for the testes. Only two animals were observed for each level of exposure in both groups so that individual animal variation must be kept in mind as a factor but nevertheless the differences were consistant.

In the adrenals, small areas of proliferation of capsular cells were observed in the female mice. In view of the progressive ovarian atrophy in these mice it may be recalled that similar adrenal cortical changes have been reported to precede the development of cortical adenomas following early gonadectomy in mice.

II. California Project

Tracer studies with Cesium and Barium are approaching completion, and are being continued with Yttrium, Columbium, and Zirconium. Additional studies are now in progress with Cerium and tracer studies with Tellurium will be started as soon as the chemical isolation of Te^{121} is completed. Radio-Autographic, Emanation, and Decontamination studies are being continued.

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E. ASSOCIATED PROJECTS

V. M.C.E. - E. E. Spencer, Chief

Biological Action of Gamma and X-Radiation

E. Lorenz, W. E. Heston, M. K. Doringer
and A. Eschenbrenner

1. Continuous exposure for 8 hours daily. Approximate doses up to date (mice): 2250 r, 1125 r, 560 r, 280 r. and 33 r (acute exposures not added). Approximate doses up to date (guinea pigs) 2250 r, 1120 r, 560 r, 280 r, and 33 r (acute exposure not added). Approximate doses up to date (rabbits) 1550 r, 775 r, 360 r, 180 r, and 18 r (acute exposures not added). Approximate dose up to date of inbred strain guinea pigs (family 2) exposed since November 6, on 8 r per 8 hour level, 390 r. Approximate dose up to date of hybrid guinea pigs exposed since December 3 on the 8 r per 8 hour level 170 r.

The experiments are progressing according to schedule. Blood changes will be discussed under item 6. One guinea pig of the 8 r per 8 hour level (2 out of the original 18 are still alive) and 2 guinea pigs of the 4 r per 8 hour level were killed and autopsied when their condition became moribund. Gross findings see under item 5. On December 3, 6 male and 6 female hybrid guinea pigs from the same colony as the original ones were placed on the 8 r per 8 hour level to obtain additional data on the radiation effects.

Results of Breeding Experiments
Summary up to date (12-23-43)

Males 8 r level

Total dose 1600 r Number of males 16 8 mated, 8 autopsied	Females to which irradiated males were mated remained non-pregnant until at least 8 weeks past irradiation after which 2 have become pregnant. 1 litter of 11.
Total dose 1000 r Number of males 16 8 mated, 8 autopsied	Males were mated 2 months after removal from field. Ave. litter size 8.2 4 remated 2 mo. later. Ave. litter size 8.2
Total dose 800 r Number of males 16 8 mated, 8 autopsied	Males mated 2 months after removal from field. Ave. litter size 3.6. 4 remated 2 mo. later. Ave. litter size 10.
Total dose 600 r Number of males 16 8 mated, 8 autopsied	Males mated on removal from field. Average litter size 7.5. 4 remated 2 mo. later, Ave. litter size 9.1. 4 again remated 2 mo. later, Ave. litter size 10.5

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[illegible] level

Total dose [illegible] r Number of males - [illegible] [illegible] mated, 2 autopsied	Results not yet available
Total dose [illegible] r Number of males - [illegible] [illegible] mated, [illegible] autopsied	Males mated on removal from field. Ave. litter size [illegible]
Total dose [illegible] r Number of males - [illegible] 8 mated, 8 autopsied	Males mated on removal from field. Ave. litter size 7.7

Males 2 r level

Total dose 600 r Number of males - 16 8 to be mated, 8 to be autopsied	Results not yet available

Females 8 r level

Total dose 500 r Number of females - 16 Mated 28 days after removal	Ave. litter size 5.9. 8 autopsied after 1st litter. 8 remated - ave. litter size 6.6 (Inc.). Controls-Ave. litter size 8.66

Females 4 r level

Total dose 500 r Number of females - 16 Mated 28 days after removal	Ave. litter size 5.9 - Control 8.6, 8 autopsied after 1st litter. 8 remated - Ave. litter size 5.7 (Inc.)
Total dose 400 r Number of females, 15 7 mated 40 days after removal 8 mated 34 days after removal	Ave. litter size 7.6 - Control 8.6, 7 autopsied after 1st litter, 8 remated Ave. litter size [illegible], 8 again remated Ave. litter size [illegible] (Inc.).
Total dose 300 r Number of females- 16 Mated 28 days after removal	Ave. litter size 9.3 - Controls 8.7, 14 autopsied after 1st litter. 2 remated Ave. litter size 8.0, 2 again remated - Ave. litter size 8.5.

Nothing further to report on histological findings of breeding experiments.

2. Continuous exposure for 24 hours daily. Breeding results.

Summary up to date

Males 4 r level

Total dose [illegible] r Total number males - 15 7 mated, 8 autopsied	Ave. litter size 9.0 4 remated. Ave. litter size 10.1
Total dose 800 r Total number males - 15 7 mated - 8 autopsied	Average litter size 9.3

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Total dose 800 r
Total number of males - 15
7 mated - 8 anticipated

Average litter size 7.4

Females 8 r level

Total dose 800 r
Total number females - 15
15 mated 28 days after removal

Average litter size 2 (Inc.) Only 4 have had litters after being mated approximately 1.5 mo. Ave. litter size controls - 8.57

Total dose 600 r
Total number females - 14
All mated 28 days after removal.

Average litter size 7.5
Ave. litter size controls - 8.66

Total dose 500 r
Total number females - 15
All mated 28 days after removal

Average litter size 7.8
Ave. litter size controls - 8.5

Total dose 400 r
Total number females - 15
All mated 28 days after removal

Average litter size 7.2
Ave. litter size control 8.1

Total dose 300 r
Total number females - 15
All mated 28 days after removal

Average litter size 7.3
Ave. litter size control 7.4

Females 4 r level

Total dose 500 r
Total number females - 15
All mated 28 days after removal

Average litter size 7.7
Ave. litter size control 8.7

Total dose 400 r
Total number females - 14
All mated 28 days after removal

Average litter size 8.6
Ave. litter size control 8.57

Total dose 300 r
Total number females - 15
All mated 28 days after removal

Average litter size 8.6
Ave. litter size control 8.66

Total dose 200 r
Total number females - 15
All mated 28 days after removal

Average litter size 8.46
Ave. litter size control 8.1

Total dose 100 r
Total number females 15
All mated 28 days after removal

Average litter size 8.4
Ave. litter size controls 7.6

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Females 2 r level

Total dose 500 r
Total number females - 16

Results not yet available

Total dose 400 r
Total number females - 14
All mated 28 days after removal

Average litter size 6.2
Ave. litter size control 6

Total dose 300 r
Total number females 15
All mated 28 days after removal

Average litter size 7.7
Ave. litter size control 8.8

Total dose 200 r
Total number females 15
All mated 28 days after removal

Average litter size 9.0
Ave. litter size control 8.57

Total dose 100 r
Total number females 14
All mated 28 days after removal

Average litter size 8.9
Ave. litter size control 8.1

Females 1 r level

Total dose 300 r
Total number females 14
All mated immediatedly after removal

Average litter size 3.7 (Inc)
Only 12 have had litters after 6 mo.
Ave. litter size control 3.9

Total dose 200 r
Total number females 14
All mated 28 days after removal

Average litter size 4.0
Ave. litter size controls 6

Totalddose 100 r
Total number females 15
All mated 28 days after removal

Average litter size 7.66
Ave. litter size control 8.57

Females 0.5 r level

Total dose 100 r
Total number females - 15
All mated 28 days after removal

Average litter size 4.1 (Inc)
Ave. litter size control 6

Nothing further to report on the histological findings of these breeding experiments.

To test the influence of age the following experiments are being conducted:

16 females entered 4 r/day field at 3 mo. of age and received a total dose of 400 r. 8 have been mated and remaining 8 will be mated at 28 days after removal.

16 females entered 4 r/day field at 4 mo. of age and received a total dose of 400 r. 8 have been mated and remaining 8 will be mated at 28 days after removal.

16 females entered 4 r/day field at 5 mo. of age and are to receive a total dose of 400 r.

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3. Continuous exposure for 8 hours daily plus daily acute exposure of 5 r given in one hour.

These experiments are being continued; the blood picture is still essentially normal after a total exposure of approximately 1050 r. Although a number of these animals show signs of chronic pneumonia (loss of weight, labored breathing) the blood picture does not seem to be affected by it. So far the experiments indicate that the dilution of the dose (5 r in one hour) is still great enough to produce effects very similar to those obtained with much greater dilution (e.g. 4 r per 8 hours or 4 r per 24 hours). This is also borne out by the breeding experiments which so far gave the following results:

Total dose 300 r Number of females - 3 All mated immediately after reaching total dose of 300 r	Average litter size 7.6 Remated average litter size 9 (Inc)
Total dose 400 r Number of females - 3 All mated immediately after reaching total dose of 400 r	Average litter size 8.0 Remated average litter size 6.0(Inc)
Total dose 700 r Number of females - 3 All mated immediately after reaching total dose of 700 r	No results as yet

4. Single acute whole body exposure of 300 r

Total dose 300 r Number of females 7 All mated immediately after irradiation	Average litter size 6.1

5. Pathology

8 r per 8 hour level. Final Report on complete series

Observations after 2, 4, 6 and 8 months (2 male and 2 female mice each)

Approximate total dose: 500 r, 1000 r, 1500 r and 2000 r.

Bone marrow: Active, no atrophy or fibrosis through 8 months.

Spleen: Appears the same in all exposures. Contains about normal number and size of Malpighian bodies. The latter contain a variable but always small amount of necrotic debris in very small foci.

Lymph nodes: Grossly, smaller than normal in all exposures. Microscopically, at two months all nodes contain several small follicles and one or two giant follicles densely packed with small lymphocytes and inconstantly containing small foci of necrotic debris. At four months the giant follicles assume a manifold appearance due to a decrease of small lymphocytes. No additional change is seen at six or at eight months.

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Testes: Grossly, at 2 months they appear normal, at 4 months they appear slightly decreased in size, at six months this decrease becomes definite and at 8 months marked. Microscopically, a questionable decrease of tubular area relative to area of interstitial tissue appears at two months and becomes definite at 4 months. At 4 months a few tubules contain only Sertoli cells, although most of them show active spermatogenesis. The number of spermatogonia-free tubules is increased at six months, although in a few spermatogenesis continues to the stage of mature spermatozoa. At eight months this tubular atrophy seems more marked but still, a few mature spermatozoa are seen. No spermatozoa were seen in the epididymis at six or at eight months. The progressive change in ratio between amount of interstitial and tubular tissue in the testes is considered for the present to be a reflection of absolute decrease in tubular area and only a relative increase in interstitial tissue.

Ovaries: At two months the ovaries appear essentially normal, containing numerous small and large developing follicles. At four months the organ is smaller than normal and contains only a few follicles and none of these is large. At six months no follicles were seen in serial sections of ovaries of two animals. At eight months the ovaries are small, and contain no follicles. Large and small cysts containing blood or amorphous coagulated material are present reported last month as possible ovarian tumors. The germinal epithelium is thrown into folds in places giving the appearance of invagination.

Adrenals: No changes were noted in the males. In the females, at six months there is slight proliferation of capsular cells in places. This is rather marked at eight months. The fusiform capsular cells extend downward in the cortex of the gland, isolating cords of the zona fasciculata. No definite adenomas are seen.

4 r per 8 hour level. Final report on complete series.

Observations after 2, 4, 6 and 8 months (2 male and 2 female mice in each).

Approximate total dose: 250 r, 500 r, 750 r and 1000 r.

Bone marrow: Lymph nodes and spleen: Same as in the 8 r per 8 hour group.

Testes: Grossly, the testes appear normal up to eight months when they appear slightly decreased in size. Microscopically, no definite change is seen at 2 months. At four months there is a change in the ratio of estimated area of tubular and interstitial tissue and is considered to reflect an absolute decrease in tubular area and only a relative increase of interstitial tissue. This becomes slightly more accentuated at 6 and at 8 months but at 8 months is still not as great as the 8 r per 8 hour group showed at 4 months. As contrasted further with the 8 r per 8 hour group, no tubules are found that are devoid of spermatogonia.

Ovaries: At two and four months no definite change is observed, there being numerous developing follicles. There may be fewer of these at four than at two months, but they have not been counted. At six months the developing follicles are definitely decreased in number, only 3 or 4 being seen in serial sections of the ovaries and those are small. No follicles are seen at eight months. There is slight invagination of the germinal epithelium at six and at

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eight months, as contrasted with the finding of several follicles in both animals of the 8 r per 8 hour group at four months.

A Adrenals: No changes were noted in the male mice. In the female mice slight proliferation of capsular cells was observed in places at six and at eight months.

Guinea Pigs:

Only gross observations on three guinea pigs are available to report upon to supplant the general summary included in the previous preport. These were essentially the same in two animals that received 4 r per 8 hour/day for a total of approximately 1100 r, and in one that received 8 r per 8 hour for a total of approximately 2100 r, and consisted of the appearance of scattered subserosal ecchymoses in the upper half of the small intestine, of small hemorrhagic lymph nodes and of pale fatty bone marrow.

6. Hematology

All mice exposed on the 4 r per 8 hours, 2 r per 8 hour, 1 r per 8 hour and 0.1 r per 8 hour levels show an essentially normal blood picture as compared to that of the controls, the total white count fluctuating between 4000 and 10,000. Two groups (out of 6) of the 0.1 r per 8 hour level show a persistently low total white count between 3000 and 5000 with all other counts normal. No explanation for this low white count can be given. The total white count of all mice on the 8 r per 8 hour level is lower than normal between 1000 and 5000, with the females lower than the males. Red count, hemoglobin and platelets are slightly lowered. This is in agreement with the histological findings which show only slight if any, changes in bone marrow and lymph nodes.

All guinea pigs exposed on the 2 r per 8 hour, 1 r per 8 hour and 0.1 r per 8 hour levels show an essentially normal blood picture with a total white count fluctuating between 5000 and 10,000. The guinea pigs on the 4 r per 8 hour level show a white count lower than normal fluctuating between 4000 and 6000. The differential count is essentially normal. Some animals show a decrease in the red count and platelets. Two of these animals developed anemia and had to be killed. The terminal count of these animals was as follows: RBC 1 million and 2 million; platelets 70,000 and 46,000, total white count 1150 and 2300, both showed relative lymphocytosis. Both were females, they had received approximately 1200 r. It is interesting to note that many animals of the 8 r per 8 hour level had to be killed on account of anemia after receiving approximately the same dose. The gross pathological picture was identical in all cases. The conclusion can be drawn that so far as the blood picture is concerned the daily doses are cumulative for guinea pigs exposed to 8 r per 8 hours or 4 r per 8 hours. The 2 guinea pigs, one male and one female, still alive on the 8 r per 8 hour level, which have received so far 2250 r show a total white count only slightly lower than normal, in both the red count is 3 million. The platelet count is 100,000 or 190,000 respectively. No essential change has occurred in their counts during the last month.

The blood picture of the rabbits on all level is essentially normal with the exception of the rabbits exposed on the 8 r per 8 hour level which show a total white count somewhat lower than that of the control and other experimental rabbits.

II. CALIFORNIA PROJECT
J. G. Hamilton and Associates

A. TECHNICAL PROGRESS REPORT ON THE METABOLIC STUDIES OF FISSION PRODUCTS

I. YTTRIUM (Y^{86})

The new series of lung studies are now under way and when completed will be reported with the intramuscular experiments.

II. RADIO-AUTOGRAPHIC STUDIES

Lung Radio-Autographs on Y^{86}, Cb^{93}, Zr^{93}, and $Ce^{>140}$ are being prepared. Miss Axelrod has recently returned from Chicago where she spent two weeks with Dr. Bloom's staff for the purpose of learning the methods of preparing bone sections. She is shortly to initiate a series of radio-autographic studies for the purpose of determining the distribution of the long-lived fission products in the skeleton. The aim of these experiments is to correlate the distribution of these substances in bone to its histological structure.

III. COLUMBIUM (Cb^{93})

The assays have now been completed with the various groups of intramuscular and lung animals receiving this substance for intervals up to and including sixteen days. As has been indicated in earlier and preliminary experiments the skeleton is the primary organ of deposition. However, the per gram content of liver and kidney is approximately that of bone even up to sixteen days. The elimination is more rapid than Zirconium and at the end of sixteen days 10% was excreted in the urine and 21.5% in the feces. The retention in the lungs following intrapulmonary administration was very high. The quantities retained at 1, 4, and 16 days were 75%, 58%, and 51% respectively. The distribution of the absorbed fraction was similar to that observed with the intramuscular animals.

IV. CESIUM (Cs^{135})

The tracer studies have almost been completed and assays are now being run on the 64 day groups of intramuscular, oral, and lung. Cesium is absorbed almost completely from the digestive tract and its distribution is essentially the same as that following intramuscular injection in that there is no striking selective deposition in any of the tissues. At the end of 64 days less than 10% of the administered dose was retained by both the oral and intramuscular groups of animals. Elimination by way of the kidney is slightly greater than the fecal excretion. No significant pulmonary retention was observed.

V. BARIUM (Ba^{140})

The assays are now being concluded with the 32 day group of animals. It is anticipated that a report on this work will be available shortly.

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VI. ZIRCONIUM (Zr^{89})

The tissue samples for the experiments with this radio-element are to be assayed within the next few weeks. The samples have been allowed to age in order to permit the decay of the Cb^{93} which was produced during the time the Zr^{93} was present in the animals prior to their sacrifice.

VII. DECONTAMINATION STUDIES Dr. Greenberg and Dr. Copp

A series of experiments are now under way to determine the quantitative relationship between the Calcium content of the diet in rats and the oral uptake of Strontium. Preliminary results indicate that the oral uptake in animals, whose previous diet has had a Calcium content approximate to that for the average human diet, is of the order of from 50% to 60%. A series of decontamination studies with Yttrium and Cerium have been initiated.

VIII. EMANATION STUDIES

Two emanation experiments have been completed under the conditions previously described in the October progress report. In both groups of animals sacrificed immediately after exposure and at the end of four days the skeleton was the chief site of deposition of the absorbed activity. Lung was the next most active tissue per gram weight in both types of experiments. Histological examination of the lungs of these animals reveal no changes which might have been due to radiation. An assay of the active deposits collected from the exhaust of the system containing the animals revealed that approximately 95% of the total activity was Barium and Strontium. The active deposits from the second experiments are now being assayed. This preliminary result would indicate that the gaseous parents of Yttrium, Zirconium, and Cerium probably have half-lives of less than 10 seconds.

IX. TELLURIUM (Te^{121})

An Antimony target has been bombarded for the preparation of Te^{121} and at present the chemists are engaged in the isolation of this radioactive isotope of Tellurium free from inert carrier.

X. PROJECTED STUDIES FOR THE NEXT TWO MONTHS.

Tracer studies are to be continued with Yttrium, Columbium, Zirconium, Cerium, Cesium, and Barium. Tracer experiments with Tellurium will be initiated. Emanation experiments, Radio-Autographic studies, and the decontamination program are to be continued.

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