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Radiation Laboratory

MEDICAL AND HEALTH PHYSICS QUARTERLY REPORT

January, February, March 1956

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MEDICAL AND HEALTH PHYSICS QUARTERLY REPORT

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STUDIES OF RADIOACTIVITY AND IRRADIATION

Joseph G. Hamilton, M.D., in charge

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ASTATINE STUDIES AND RELATED WORK

SKELETAL DEPOSITION OF THE LANTHANONS

C. Willet Asling, Patricia W. Durbin, Muriel E. Johnston, and Nylan Jeung

The lanthanide and actinide elements are deposited in the skeleton of the adult rat in amounts varying from 25% to 60% of the administered dose.[1,2] The skeletal accumulation of any individual trivalent element appears to depend at least qualitatively upon the radius of plus three ion. It has been fairly well established that the skeletal deposition site is closely associated with the osteoid matrix,[3] the periosteum, endosteum, and on the surfaces of calcified cartilages.[1,4] There is, however, no demonstrable deposition of the lanthanides in resting cartilage.[1,3,4]

To further explore the problems of the deposition of lanthanide in bone, experiments have been initiated using Ce^{144} as the prototype of the light lanthanide group, and 17- to 20-day fetal rats as test animals. Ce^{144} was chosen because of its ready availability in carrier-free form, long half life (280 days), and radiation characteristics. The fetal rat was selected

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[1] J. G. Hamilton, The Metabolic Properties of Fission Products and Actinide Elements, Revs. Modern Phys. 20, 718-728 (1948).

[2] Durbin, Williams, Gee, Newman, and Hamilton, Metabolism of the Lanthanon in the Rat, Proc. Soc. Exptl. Biol. Med. 91, 78-85 (1956).

[3] Copp, Hamilton, Thomson, and Cramer, Trans. Macy Conf. on Metabolic Inter-relations, 3, 226-258 (1951).

[4] Asling, Hamilton, Heller, and Louie, The Localization of Certain Alkaline and Rare Earth Elements in the Costochondral Junction of the Rat, Anat. Rec. 113, 285-300 (1952).

for the test system, because bone can be found (particularly in the vertebral column) in all stages of development, and in all stages of calcification in the same specimen, and also because the minimal degree of calcification permits the use of routine paraffin embedding and sectioning techniques preparatory to mounting for radioautographs.

Preliminary tracer studies showed that only minute amounts of Ce^{144} were transferred from the maternal blood stream across the placental barrier to the fetuses. This amounted to less than 2% of the administered dose at 24 hours, even though the Ce^{144} was administered intravenously in three separate doses to keep the maternal blood cerium at a relatively high level. Since that time, fetuses have been injected directly via the blood vessels in the umbilical cord. After injection the cord is tied, and the fetuses are kept alive on warm saline gauze for period ranging from 5 to 30 min. They are then fixed in 80% alcohol. Whole fixed specimens are either cut sagitally and embedded in paraffin for histological preparation, or are dissected for radioactive assay.

Radioautographs are prepared either with industrial x-ray film or Eastman Kodak stripping film of the NTB or NTA varieties. Alternating sections are stained with hematoxylin and eosin, with Van Kossa's silver stain for calcium counterstained with H and E, or with a variation of the periodic acid Schiff stain for mucopolysaccharides.

The results obtained to date indicate that Ce^{144} deposition in bone depends upon the breakdown of cartilage prior to actual calcification. A preliminary observation, which will be explored further, is the affinity for Ce^{144} of the mucous membranes in the fetal gastrointestinal tract. It is also interesting to note that the livers of the younger fetuses (less than 18 days), which are still actively engaged in blood formation, failed to accumulate Ce^{144} to any significant degree.

EXCRETION OF CERIUM-144

Marilyn Williams, Nylan Jeung, and Patricia W. Durbin

It has been well established that carrier-free isotopes of the light lanthanons are primarily accumulated in the liver (50% or more of the administered dose in 24 hours).[1,2] During the subsequent 60 days, most of the lanthanons disappear from the liver and can be accounted for in the feces. With Ce^{144} used as a representative of the group,[5] it has also been established that the renal excretion rate is dependent upon the lanthanon level in the blood. The fecal excretion does not appear to be dependent upon blood level. This observation has led to the proposition that cerium and other light lanthanons are removed from the liver via the bile, and having made their way into the gastro-intestinal tract are so combined with other materials in the tract that they cannot be reabsorbed.

[5] Durbin, Asling, Johnston, Hamilton, and Williams, "The Metabolism of the Lanthanons in the Rat. II. Time Studies of the Tissue Deposition of Intravenously Administered Radioisotopes," UCRL-3191, Nov. 1955.

Experiments are currently under way to test this hypothesis. Some preliminary observations are as follows:

(a) bile collected from rats provided with biliary cannulas during the most rapid period of fecal cerium excretion showed a small Ce^{144} concentration; this concentration is, however, completely insufficient to account for that which appears in the feces of normal rats during the same time interval;

(b) rats in which the bile ducts have been ligated prior to Ce^{144} administration continue to excrete Ce^{144} in the feces;

(c) fecal Ce^{144} is probably in an inorganic state;

(d) biliary Ce^{144} appears to be very weakly complexed, if at all, and can be completely removed from freshly collected bile from Ce^{144}-injected rats by shaking it with the hydrogen form of Dowex-50 resin.

Experiments are currently under way to explore the possibility of direct excretion of Ce^{144} into the g-i tract and to determine whether various types of cathartics alter the rate at which the lanthanons are excreted in the feces.

THE TOXICITY OF INTRAMUSCULARLY ADMINISTERED RADIUM-223

Patricia W. Durbin, George Barr, Marilyn Williams, and Nylan Jeung

A preliminary study of some of the quantitatively measurable radiation effects of intramuscularly administered Ra^{223} (half life: 11.2 days) was reported in 1954.[6] Mortality, body weight, red blood cell count, white cell count, hematocrit, and hemoglobin of two low-level groups were followed for a period of seven months, and of two medium-level groups for five months. It was reported at that time that an outbreak of pneumonia necessitated termination of the experiment. Although ten rats were started in each dose group, manpower was not available to perform routine blood counts on more than five rats per group on any one day, so that the blood data presented were not considered adequate.

In accordance with experiments described earlier,[7] comparing internal alpha and beta irradiation from elements that are deposited in the same organ systems for nearly equal lengths of time, a second study of the toxicity of Ra^{223} was initiated. Young adult female Sprague-Dawley rats (approximately 200 g weight) were used as the test animals. Dosages ranged from 0.004 to 0.10 μc/g of Ra^{223}. Each dosage group contains ten animals.

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[6] Hamilton, Durbin, Williams, Newman, and Gee, "Lanthanide and Heavy Elements," in UCRL-2661, July 1954.

[7] Hamilton, Durbin, and Jeung, "Comparison of the RBE of Alpha-Beta-Particle Irradiation of the Hematopoietic System," in UCRL-2418 Nov. 1953.

Measurements include red blood cell count, red blood cell diameter, white blood cell count, differential white cell count, hemoglobin, microhematocrit, body weight, gross appearance, Ra^{223} excretion, and mortality. Aureomycin is being administered two days weekly in the drinking water in order to keep pneumonias and other chronic respiratory infections under control.

Another experiment is also under way to study the acute effects (at 8 days) of Ra^{223}. The measurements here include gross observation of and weight of internal organs, histological examination of a selected group of tissues, and the utilization by the red cells of Fe^{59}.

THE EFFECT OF SURGICAL AND RADIOTHYROID-PARATHYROIDECTOMY WITH IODINE-131 AND ASTATINE-211 ON BREEDING IN THE FEMALE SPRAGUE-DAWLEY RAT

Marshall W. Parrott

An experiment which terminated in the failure of a group of Sprague-Dawley rats to breed, following administration of a partial thyroidectomizing dose of At^{211},[8] suggested that further investigations might provide additional insight into this failure to breed, apart from the effects of chronic hypothyroidism. It was decided that the effects on reproduction of surgical thyroid-parathyroidectomy and radiothyroid-parathyroidectomy with I^{131} and At^{211} would be compared. Concomitantly, we may obtain further information on the systemic effect following the administration of At^{211}.

The following regimen was developed to interlace all results obtained so that each step will act as a control for one or more of the other steps.

(a) Surgical thyroidectomy -- both thyroid and parathyroid disturbed.[10]

(b) Surgical thyroidectomy with subsequent thyroxine supplement-- involves only parathyroidal effects.

(c) Thyroidectomy with I^{131} -- both thyroid and parathyroid disturbed; some radiation effects to reproductive organs may be present.[9]

(d) Thyroidectomy (partial) with At^{211} -- parathyroids intact or at least functional; radiation effects and thyroid damage present.[9]

(e) Thyroidectomy (partial) with At^{211} with subsequent thyroxine supplement-- parathyroids intact or at least partially functional, thyroid augmented; only radiation effects should be noted.

(f) Normal controls.

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[8] Parrott, Durbin, and Hamilton, "The Effect of Therapeutic Doses of At^{211} on the Reproduction and Development of the Sprague-Dawley Rat," in UCRL-3268, 1955.

[9] Hamilton, Durbin, and Parrott, "Comparison of Acute and Chronic Changes Produced in Rats by I^{131} and At^{211} at Lethal Levels," Proc. 2nd Radioisotope Conf. Oxford, July, 1954.

[10] E. J. Farris and J. Q. Griffith, Jr., "The Rat in Laboratory Investigation," 2nd Ed. 439-441 and 166-167 (1949).

In an effort to determine completeness of thyroidectomy, and the effectiveness of intragastric administration of desiccated thyroid (2.88 mg every 2 days), basal metabolic rates are being determined for each of the aforementioned groups of rats according to Watts' modification[11] of the method described by Kleiber.[12]

REPORT ISSUED

Results of a study of I^{131} toxicity survival in rats are to be presented in two papers. The first of these, "Long-Term Sequelae of Massive Doses of Iodine-131. I. Histopathological Findings," by C. Willet Asling, Muriel E. Johnston, Patricia W. Durbin, and Joseph G. Hamilton, has been issued as UCRL-3398.

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[11] R. W. E. Watts, "Metabolic Rate Changes Following Thyroid Destruction by At^{211} and I^{131} in the Rat," Proc. Soc. Exptl. Biol. Med. 89, 220-222 (1955).

[12] M. M. Kleiber, "A Respiration Apparatus for Serial Work with Small Animals, Particularly Rats," Univ. of Calif. Publ. in Physiol. 8, (1932-51).

RADIATION CHEMISTRY

Warren M. Garrison in charge

Boyd Weeks, Michael Jayko, Winifred Bennett,
Joseph Ward, and Sibyl Cole

ACETIC ACID

The radiation-induced oxidation of acetic acid in dilute, oxygen-aerated aqueous solution gives carbon dioxide, formaldehyde, glyoxylic acid, glycolic acid, and oxalic acid as major decomposition products.[1,2] Succinic acid, the principal organic product in oxygen-free solutions,[3] is not observed. A mechanism proposed[2] to account for these results involves the formation of the peroxy radical O_2CH_2COOH through reaction of O_2 with the intermediate CH_2COOH, which, in oxygen-free solutions, dimerizes to give succinic acid. A detailed study of product yields in oxygen-aerated acetic acid solutions is being made to obtain additional information on the properties of the intermediate peroxy radicals and the mechanism of the oxidation processes.

A study of product yields as a function of radiation dosage for 40-Mev helium-ion irradiation has just been completed. The experimental techniques and analytical procedures involving C^{14} tracer methods were those described in previous reports.[3,4] Although not all the necessary calculations have yet been completed, the available data show that G values[5] for glycolic acid and oxalic acid are essentially independent of doses up to $\sim 5 \times 10^{20}$ ev/ml. The corresponding yield data for glyoxylic acid show a decrease in G with increasing dose. The specific-yield values for carbon dioxide increase rapidly with dose. These results indicate that the oxidation path does not involve the sequence: acetic, glycolic, glyoxylic, oxalic, carbon dioxide. The observed decrease in glyoxylic acid and the corresponding increase in carbon dioxide is attributed to the "dark reaction"[2]

$$CHOCOOH + H_2O_2 \rightarrow CO_2 + HCOOH + H_2O.$$

The detailed mechanism of the radiation-induced reaction is to be discussed in a forthcoming report.

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1 Garrison, Haymond, and Weeks, Rad. Res. 1, 97 (1954).

2 H.R. Haymond, Some Effects of Dissolved Oxygen on the Heavy-Particle Irradiation of Aqueous Acetic Acid (Thesis) UCRL-2697, Sept. 1954.

3 Garrison, Haymond, Morrison, and Weeks, J. Am. Chem. Soc. 75, 2459 (1953); ibid 77, 2720 (1955).

4 Medical and Health Physics Quarterly Report, UCRL-3096, July 1955.

5 Molecules of product per 100 ev absorbed energy.

FORMIC ACID

The production of glyoxylic, glycolic, oxalic, tartronic, mesoxalic, and tartaric acids in the cyclotron irradiation of oxygen-free formic acid solutions is now being studied as a function of formic concentration, pH, beam intensity, and radiation dose. It has been proposed[6] that formation of these higher-molecular-weight products (which are not obtained in γ-ray irradiations under similar conditions) can be interpreted in terms of a preliminary formation of glyoxylic acid. The experiments now in progress will provide additional information on the mechanisms of reduction and synthesis.

AMINES

The radiation-induced oxidation of simple amines in dilute oxygen-aerated aqueous solution has been represented[4] by the stoichiometry

$$RCH_2NHR + O_2 + H_2O \rightarrow RCHO + RNH_2 + H_2O_2.$$

Preliminary discussions of mechanism have been presented (UCRL-3096, UCRL-3208). Detailed studies of N-C bond rupture are now in progress. Previously developed analytical procedures are being used in the determination of carbonyl products. Ion-exchange chromatography is being investigated as a general method for the more difficult problem of separating product amine from the parent compound. The separation of ethylamine and diethylamine has been accomplished on a Dowex-50 column. The amines are selectively eluted with dilute hydrochloric acid, which is gradually increased from 2 N to 4 N to effect a maximum separation.

GLYCINE

Previous quarterly reports (UCRL-3096, UCRL-3268) have presented the main features of a proposed mechanism for indirect action of radiation on glycine in aqueous solution. In order to account fully for the observed phenomena under various conditions (presence and absence of dissolved O_2, high- and low-ionization-density radiation), a consideration of the mechanism for direct radiolysis of solute glycine is necessary. Evidence for certain direct action processes is briefly outlined below. Detailed discussion is reserved for a comprehensive report on glycine radiolysis processes (UCRL-3071) now nearing completion.

Processes induced by indirect action of H and (or) OH radicals are assumed to be involved in the formation of major products in the radiolysis of aqueous glycine[7,8,9] because the rates of product formation are observed

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[6] Garrison, Bennett, and Jayko, J. Chem. Phys. 24, 631 (1956).

[7] G. Stein and J. Weiss, J. Chem. Soc. 3256 (1949).

[8] Sharpless, Blair, and Maxwell, Rad. Res. 2, 135 (1955).

[9] W. M. Dale and J. V. Davies, Biochem. J. 48, 129 (1951).

to decline as glycine concentration is increased. For NH_3 and total organic acid, this decline in rate of increase occurs only below ~0.5 M. Above 0.5 M the specific yield G is proportional to glycine concentration. For high-ionization-density radiation (30-Mev He^{++} ions from the Crocker Laboratory 60-inch cyclotron), the specific yield of HCHO is roughly proportional to glycine concentration over the entire range 0.0625 M to 3.3 M. Moreover, the total yields for these products at high glycine concentrations are greatly in excess of those predicted solely on the basis of indirect processes. One or more direct processes yielding these products, superimposed on the indirect processes already described, are indicated.

A detailed consideration of data obtained in this laboratory and elsewhere appears to be consistent with the viewpoint that two direct rupture processes are involved. The primary and secondary processes arising from direct action are summarized below:

Primary Reaction 1

$$NH_2CH_2COOH \rightsquigarrow NH_2 + CH_2COOH$$

Secondary reactions, O_2-free

$$NH_2 + NH_2CH_2COOH \longrightarrow NH_3 + NH_2CHCOOH \text{ (or } NHCH_2COOH)$$
$$CH_2COOH + NH_2CH_2COOH \longrightarrow CH_3COOH + NH_2CHCOOH$$
$$2\ NH_2CHCOOH \longrightarrow NH{=}CHCOOH + NH_2CH_2COOH$$
$$\longrightarrow \text{Dimer}$$
$$NH{=}CHCOOH + H_2O \longrightarrow NH_3 + CHOCOOH$$
$$\longrightarrow NH_3 + HCHO + CO_2$$

Secondary reactions, O_2-saturated

$$NH_2 + NH_2CH_2COOH \longrightarrow NH_3 + NH_2CHCOOH$$
$$CH_2COOH + O_2 \longrightarrow O_2CH_2COOH \text{ (end products include } CHOCOOH \text{ and } CH_2OHCOOH \text{ ref. (1), (2))}$$
$$NH_2CHCOOH + O_2 \longrightarrow NH{=}CHCOOH + HO_2$$
$$NH{=}CHCOOH + H_2O \longrightarrow NH_3 + CHOCOOH$$
$$\longrightarrow NH_3 + HCHO + CO_2$$
$$2\ HO_2 \longrightarrow H_2O_2$$

Primary Reaction 2

$$NH_2CH_2COOH \rightsquigarrow NH_2CH_2 + COOH$$

Secondary reactions, O_2-free

$$NH_2CH_2 + NH_2CHCOOH \longrightarrow NH{=}CH_2 + NH_2CH_2COOH$$
$$\longrightarrow \text{Dimer}$$
$$COOH + NH_2CHCOOH \longrightarrow CO_2 + NH_2CH_2COOH$$
$$NH{=}CH_2 + H_2O \longrightarrow NH_3 + HCHO$$

Secondary reactions, O_2-saturated

$$NH_2CH_2 + O_2 \longrightarrow NH{=}CH_2 + HO_2$$
$$COOH + O_2 \longrightarrow CO_2 + HO_2$$
$$NH{=}CH_2 + H_2O \longrightarrow NH_3 + HCHO$$
$$2\ HO_2 \longrightarrow H_2O_2 + O_2.$$

The specific yield for Primary Reaction 1 extrapolated to 100% glycine concentration as determined from both NH_3 yields and ($H_2 + CH_3COOH$) yields in x-ray irradiation is about 9. This compares with reported[9] yield values for NH_3 obtained in the irradiation of solid glycine if due account is taken different secondary reactions. Additional evidence for this primary reaction is found in the observation that acetic acid is produced in the irradiation of solid glycine.[10] It is to be noted that the ammonia yield resulting from direct deamination of glycine in the presence of O_2 is virtually the same as in the absence of O_2. A small increase (~ 10%) in O_2 due to the blocking of dimerization reactions is realized.

It has frequently been observed that the total NH_3 yield is approximately the same for glycine solutions saturated with O_2 as for those free of O_2. It has already been pointed out that direct deamination of glycine would yield about the same amount of NH_3 in the presence as in the absence of O_2. The presence of dissolved O_2 causes a decrease in the oxidation of glycine due to oxidation of H atoms and the blocking of H_2O_2 oxidation of organic radicals. This decrease is partially but not entirely compensated by the increased efficiency of NH_3 production from the organic radicals formed. It has therefore been necessary in the past to invoke NH_3-yielding reactions of HO_2 [7] or OH with glycine in excess of the radical pair yield to account for observed ammonia yields in the presence of O_2.

It was pointed out in a previous quarterly report (UCRL-3268) that HO_2 reaction with glycine was inconsistent with observed product stoichiometry, and the suggestion was presented that glycine reacts with OH in the track, and thereby suppresses H_2O_2 formation via the forward reaction.[11] Parallel action[12] of certain inorganic ions was offered as supporting evidence.

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[10] R. M. Noller in UCRL-2455, Jan. 1954.

[11] A. O. Allen, J. Phys. and Colloid Chem. 52, 479 (1948).

[12] T. J. Sworski, J. Am. Chem. Soc. 76, 4687 (1954).

The recent observation[13] that the NH_3 yield in very dilute O_2-saturated glycine solutions is very low indicates that OH does not oxidize glycine readily enough to compete favorably with the forward formation of H_2O_2. Direct Process 2, however, obviates the necessity of assuming that glycine suppresses the forward reaction. Virtually the same products in the same yields are indicated both in the presence and absence of dissolved oxygen. However, in the O_2-free case, two organic radicals are consumed which, upon disproportionation, would have yielded NH_3 and aldehyde (or dimer) had they not been reduced to glycine by the primary radicals, NH_2CH_2 and COOH. Thus, in the absence of O_2, the gross stoichiometry of the indirect processes is unaffected. NH_3, aldehyde, and dimer yields resulting from reactions of primary reducing radicals, NH_2CH_2 and COOH, are completely compensated by an equal loss in yield of similar but not necessarily identical products of indirect processes. In O_2-saturated solutions, however, this yield of NH_3 and aldehyde is entirely in addition to that resulting from OH attack on glycine and also, of course, to that resulting from direct deamination of glycine. In experiments employing cyclotron radiations where the dose rate and the specific ionization are high, back reaction reduces the relative importance of indirect processes. Indirect formation of HCHO is negligible, and yields of HCHO in direct proportion to glycine concentration are observed. HCHO yields, obtained under such circumstances, can be considered a measure of the primary reaction yielding NH_2CH_2 and COOH. Calculations of theoretical NH_3 yield on the basis of indirect processes previously described (UCRL-3096, UCRL-3268), plus the two direct processes presented here, are equal to observed yields under both O_2-free and O_2-saturated conditions.

CHEMICAL ACTINOMETRY OF CYCLOTRON RADIATIONS

In the preceding quarterly report (UCRL-3268) results of a long-term study of the reproducibility and accuracy of cyclotron dose-yield measurements in the formic acid-oxygen actinometer were presented.[14] The H_2O_2 yields[5] for several radiation conditions were tabulated for repeated experiments over about a one-year period. Many of the irradiations in that series were carried out immediately in front of the exit window for the cyclotron beam. It has been found, however, that a small, variable, and unpredictable number of accelerated ions emerging from the cyclotron target window traverses an orbit different from the main beam. Because of the shortness of the collimator system used, these extra-orbital ions were monitored but not absorbed by the solution, and slight variable errors in exposure resulted. The procedure now in use for radiation chemical studies involves a long collimating system and a magnetically focused beam. Radiation schedules are coordinated with the schedules of another group using this elaborate equipment so as to reduce the cyclotron time consumed in setting up. Reproducibility has been improved, and a small increase in the average measured H_2O_2 yields has been observed.

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[13] E. S. G. Barron, Annals New York Acad. Science 59, 574 (1955).

[14] E. J. Hart, J. Phys. Chem. 56, 594 (1952).

The effect of stirring was reinvestigated with this modified procedure wherein deviations from average have been reduced. It was found that stirring of the solution during irradiation has no effect for 0.05 M HCOOH targets flushed with 100% O_2. Stirring of targets using aeration gases of less than 100% O_2 composition, or using HCOOH concentrations greater than 0.05 M, does appreciably raise H_2O_2 yields. Table I shows results obtained in recent experiments employing stirred and unstirred targets and the modified beam-collimation system, but otherwise carried out under the conditions described in the preceding quarterly report.

Table I

Yields of H_2O_2 (molecules per 100 ev absorbed)

Experiment No.	$G_{H_2O_2}$	Condition	Average Results
1	2.08, 2.09, 2.09	0.05 N HCOOH	Av. $G_{H_2O_2}$ = 2.057
	2.10, 2.09, 2.09	pH 3	
2	2.07, 2.05, 2.04	Stirred and unstirred	Max. dev. ±0.087
	2.04, 2.03, 2.04	100% O_2	
	2.06, 2.08		
3	2.06, 2.07, 2.03	2 to 6×10^{18} ev/ml	Av. dev. = 0.021
	2.05, 2.07, 2.06		
	1.97, 2.07, 2.06		
	2.04, 2.07, 2.01		
	2.04, 2.07, 2.04		
2	2.10, 2.03	0.05 N HCOOH	Av. $G_{H_2O_2}$ = 2.125
		pH 12	
3	2.07, 2.10, 2.07	Stirred and unstirred	Max. dev. = 0.105
	2.10	100% O_2	
4	2.13, 2.12, 2.13	2×10^{18} ev/ml	Av. dev. = 0.038
	2.15, 2.13, 2.18		
	2.18, 2.22, 2.15		
3	2.32, 2.34, 2.38	0.25 N HCOOH	Av. $G_{H_2O_2}$ = 2.36
		pH 3; 100% O_2	
	2.38	Stirred; 2×10^{18} ev/ml	

BIOLOGICAL STUDIES OF RADIATION EFFECTS

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Material for this report had not been received at the time of publication, but may be expected in a subsequent report.

HEALTH CHEMISTRY

Nelson B. Garden

The long-planned-for maneuver of establishing a more autonomous Health Chemistry group in Livermore was undertaken during this period. The group that has been in operation there since November, 1952, has consisted of a nucleus of experienced Berkeley-trained Health Chemists, and new members have been added to this group as fast as men were available. As shop, decontamination and assembly facilities for these are not yet provided, this group has been operating essentially under the guidance and responsibility of the Berkeley group, and, in the interest of safety, will have to continue heavy reliance upon Berkeley. The announcement from the Director's Office that the Livermore Health Chemistry group is now on its own happily indicates that it is approaching the desired maturity and size. However, owing to the nationwide shortage of scientifically trained personnel, utmost cooperation between the groups is still mandatory.

The major effort of the Health Chemistry group during this quarter--especially of the Equipment Development and the Airborne Activity Control group--was in processing multicurie quantities of both alpha-emitting substances and fission products, in Livermore. The equipment for this run was centered in the standard six-inch lead shield area. The work has been completed and the Health Chemistry Decontamination group has started work for disposal and reclamation of the items in the setup following its dismantling by the Equipment Development and Airborne people. Although the desired products from this run were essentially realized, the severe strain on the equipment clearly indicated that such amounts of alpha activity and its associated effects must be kept under a certain limit; the limit was approached or possibly exceeded by the size of the batches chosen for processing in this run. The appearance of unpredicted chemical phenomena, such as stable crust, foaming hydrogen peroxide, etc., caused unexpected difficulties. The run also suggested that further provision for "shine" control and neutron shielding be made, since α, n reactions with light elements produce large neutron values.

Various projects and problems at Berkeley receiving attention from the proper Health Chemistry group are listed below:

1. Design of housing for a 100-curie Co^{60} source being created in the MTR. The design is being based on that of the currently existing 100-curie source holder, which has been successfully used over the last few years.

2. Solidification of low-grade liquid waste. The gelling process currently used has met with considerable success.

3. Processing of high-activity waste by creation of solid blocks, using a Portland cement-vermiculite mixture.

4. Installation of a machine shop in Livermore for handling radioactive metals.

5. Redesign and improvement of target-handling and disassembling facilities for the increasingly active 60-inch cyclotron targets. Quantities bombarded at one time have included approximately 10 micrograms of curium, 100 micrograms of americium, and 150 milligrams of plutonium in many instances.

6. Cleanup of the six-inch cave equipment in Bldg. 70, used recently in processing irradiated plutonium, as described in the previous quarterly report.

7. Reassembly of the six-inch cave in Bldg. 70 for the next irradiated plutonium "Napkin Rings".

8. Program for further controlling target-dissolving operations in Bldg. 70, formerly adequately handled in hoods. Now the targets (mentioned in Point 5) are becoming more and more active through more efficient bombardment techniques, and larger quantities of target material are being introduced into the accelerator beams.

9. Special box in which to process astatine.

10. A high-frequency welding head for plastics, so designed that it will permit remotely controlled application to exceedingly radioactive tubing.

The disassembly and decontamination of the temporary shack known as Paydirt, behind Bldg. 5, in which was processed several tons of specially procured contaminated soils, was completed and is ready for demolishing.

Health Chemistry personnel have been studying the potential hazards introduced by the use of beryllium ions in the 60-inch cyclotron; recommendations are being made for insuring clean air in the vicinity and for facility of decontamination of cyclotron parts.

Garden

HEALTH PHYSICS

Burton J. Moyer

STATISTICAL SUMMARY OF MONITORING PROGRAM

Survey Instruments Maintained

Beta-Gamma Meters	36
I D L Meters	21
Juno logarithmic ion chamber	20
Abacus logarithmic ion chamber	30
Recording Intensity Meters	7
Victoreen proteximeter	3
Slow-Neutron Proportional Counters	15
Fast-Neutron Proportional Counter (Portable)	11
Slow-Neutron Portable Unit	4
Balanced Chamber--Fast Neutron--Portable	3
Special Tissue Wall Survey Instrument	1

Personnel Meters in Use

Total Personnel Covered with Film Badges	3748
Total Man-Days Coverage with Electroscopes	4475
Total Man-Days Coverage with Dosimeters	2675
Total Man-Days Coverage With Slow-Neutron Chambers	2465

Bevatron

1800 Electroscopes - 20 used per day for 3 months.

Crocker

1350 Slow-Neutron Chambers--15 used per day for 3 months
1350 Dosimeters--15 used per day for 3 months
1350 Electroscopes--15 used per day for 3 months

Building 53

1115 Slow-Neutron Chambers
1325 Dosimeters
1325 Electroscopes

Cases of Weekly Exposure Above 0.3r (excluding Livermore)

Weekly Film Expos. Above	184"Area	60"Area	Linac	Chem	Other	Total
0.3	0	9	4	33	2	48
0.5	0	3	0	23	2	28
1.0	0	2	0	12	0	14
1.5	0	0	0	8	0	8
2.0	0	0	0	5	0	5
2.5	0	0	0	1	0	1
3.0	0	0	0	1	0	1
4.0	0	0	0	1	0	1
6.0	0	0	0	0	0	0
6.5	0	0	0	0	0	0

BISMUTH FISSION CHAMBER

The large bismuth fission chamber and its duplicate which contains no bismuth are now connected with alternate plates in parallel. Despite the fact that the capacitance of one set of plates with respect to the other is ~6000 μμf it is possible to amplify the signal produced by the passage of a bismuth fission fragment between a set of plates. This is accomplished by inserting an inductance between each pair of signal plates, properly terminating one end of this line, and driving a pulse transformer with the other. The output of the pulse transformer is connected to the grid of the first amplifying tube. Using this technique, with a Cf^{252} source which partially decays by spontaneous fission, it is possible to achieve a Cf fission signal-to-noise ratio of greater than 5 to 1. Both chambers have been tested in a high-energy neutral beam at the Bevatron, and preliminary results indicate a significant difference in the response of these chambers, owing presumably to the presence of bismuth in the one.

Information Division
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