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MEDICAL AND HEALTH PHYSICS QUARTERLY REPORT

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MEDICAL AND HEALTH PHYSICS QUARTERLY REPORT

April, May, June 1955

July 26, 1955

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* Previous Quarterly Reports: UCRL-3013, UCRL-2881

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STUDIES OF RADIOACTIVITY AND IRRADIATION

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

Crocker Laboratory
University of California, Berkeley, California

ASTATINE STUDIES AND RELATED WORK

C. Willet Asling, Patricia W. Durbin, Muriel E. Johnston, Nylan Jeung, Marshall W. Parrott, Ruth H. Newman, and Marilyn H. Williams

Monkeys

The four rhesus monkeys that received thyroid-ablative doses of At^{211} approximately two years ago have been sacrificed. Detailed histological descriptions of these animals will be available shortly.

Rats

We are attempting to elucidate the cause of the early and high incidence of mammary tumors in rats treated with small doses of At^{211}. In October 1954, forty female Sprague-Dawley rats were given 0.5 μc/g of At^{211}. One-half of this group had previously received 230 μg/kg of thyroxine per day for eight days. To date seven tumors have been seen in the control group and nine tumors in the thyroxine-treated group. Periodic blood counts shown in Table I reveal normal white-cell counts and a moderate anemia in both control and thyroxine groups. The t-test[1] was applied to the 3-month and 8-month means for both groups. The 8-month RBC and Hb values were significantly different from the 3-month values in both groups (P=0.01), but the means for each blood element were the same for the thyroxine and control groups. The differences in WBC values for the 5-month interval were not significantly different.

In June, nine tumor-bearing animals (three controls and six thyroxines) were given tracer doses of I^{131} 24 hours prior to autopsy. The average iodine accumulation in the thyroid remnants of the control and thyroxine-treated groups was 6.0% and 5.0% respectively. The thyroids of a group of six untreated age controls accumulated 11.2% of the I^{131} dose. Despite the small numbers of animals involved, the I^{131} uptakes indicate that the thyroxine preparation employed had deteriorated during storage, making it ineffective in the reduction of thyroidal At^{211} uptake to the levels obtained by Shellabarger et al.[2] This experiment will be repeated during the next quarter with a thyroxine preparation of known potency.

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[1] G. Snedecor, Statistical Methods, The Collegiate Press, Ames, Iowa, 1948.

[2] C. J. Shellabarger, P. W. Durbin, M. W. Parrott, and J. G. Hamilton, "Effects of Thyroxine and KSCN on Capacity of Rat Thyroid Gland to Accumulate At^{211}," Proc. Soc. Exptl. Biol. Med. 87, 626-629 (1954).

Table I

Red cell count, white cell count, and hemoglobin concentration of female Sprague-Dawley Rats treated with 0.5 μc/g At^{211} at age 55 days. Controls received only At^{211}. Thyroxine rats received 230 μg/kg/day l-thyroxine subcutaneously for 8 days prior to At^{211} administration. There were 20 rats in each group unless otherwise specified. Means are shown with their standard errors.

		Months Postinjection		
		3	6	8
Red Cell Count ($10^6/mm^3$)	Control	7.5 ± 0.17	7.1 ± 0.19	6.6 ± 0.32*
	Thyroxine	7.3 ± 0.16	7.2 ± 0.20	6.6 ± 0.18
Hemoglobin (g/ml whole blood)	Control	15.2 ± 0.17	14.2 ± 0.18	13.0 ± 0.54*
	Thyroxine	14.8 ± 0.16	14.3 ± 0.76	13.7 ± 0.16
White Cell Count ($10^3/mm^3$)	Control	10.4 ± 0.57	10.1 ± 0.82	9.6 ± 0.62*
	Thyroxine	12.1 ± 0.61	11.2 ± 0.71	10.9 ± 0.61

* Four animals in the control group were autopsied between the sixth and eighth month.

Forty female Sprague-Dawley rats were given 0.5 μc/g of At^{211} in April 1955, and on the sixth day postinjection, one-half of the animals were placed on a maintenance dose of thyroxine (2 μg per day per rat administered in the drinking water.)[3] The time elapsed since the group was injected is too short for the development of tumors. The thyroxine preparation is made fresh weekly from dry crystalline Squibb l-thyroxine. The potency is being checked routinely every two to three weeks by determining its ability to lower the thyroidal uptake of I^{131}.

IODINE

Several groups of rats were injected 18 months ago with massive amounts of I^{131}, 10 to 90 μc/g body weight. The survivors have been sacrificed within the last 3 months. Pathological material from the four lowest dose levels should be available shortly.

RARE EARTHS

The differences in skeletal deposition of the light and heavy lanthanons have been described by Durbin et al.[4] Further studies in the deposition of four long-lived lanthanons are currently under way.

Radioautographs of undecalcified long bones are being prepared from rats that received Ce^{144}, $Eu^{152,154}$, Th^{160}, and Tm^{170} 4 and 30 days prior to sacrifice.

Groups of six female rats (60 days old) were given one of the above lanthanon isotopes intramuscularly and sacrificed 4 days later; the long bones from one hind leg were dissected free from muscle, weighed, and placed as a unit into bottles containing 10 ml of 5% nitric acid in 80% alcohol for decalcification. The solutions were changed daily, until decalcification was complete, for 6 days. The daily changes of decalcifying fluid and the completely decalcified bones were assayed for radioactivity.

The results of these assays are shown in Table II. In all cases, the difference between each mean percent acid-stable lanthanon and the mean immediately below it was statistically significant. Bone weights were uniform for all 24 rats used and averaged 1.30 g. Uniformity of age and bone weight would appear to rule out bone growth activity as a factor in the cause of these differences. It would appear that the heavy lanthanons represented by thulium are more firmly bound to the osteoid matrix than are the light lanthanons represented by cerium.

We are attempting to prepare relatively pure chondroitin sulphuric acid (an important constituent of bone protein) in order to determine the properties of its complexes with the lanthanons.

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[3] I. L. Chaikoff, and A. Taurog, "Studies on the Formation of Organically Bound Iodine Compounds in the Thyroid Gland and their Appearance in Plasma as shown by the Use of Radioactive Iodine," Ann. N. Y. Aca. Sci. 50, 377-400(1949).

[4] P. W. Durbin, M. H. Williams, M. Gee, R. H. Newman, and J. G. Hamilton, "The Metabolism of the Lanthanons in the Rat," University of California Radiation Laboratory Report No. UCRL-3066, 1955.

Table II

The stability of skeletally deposited lanthanon to acid-alcohol decalcification. Values are expressed as percent of administered dose and as percent total lanthanon in bone samples. Mean values for six rats are shown with their standard errors.

	% dose in leg bone	% lanthanon in bone stable to acid alcohol*
Ce^{144}	2.17 ± 0.08	54.2 ± 1.6
$Eu^{152, 154}$	2.36 ± 0.06	60.8 ± 1.7
Tb^{160}	4.92 ± 0.10	69.8 ± 0.9
Tm^{170}	4.91 ± 0.17	89.7 ± 0.8

* The t-test[1] was applied to each succeeding pair of means and the P value was beyond the 1% limit of confidence.

REPORTS ISSUED

A compilation of the work done in this laboratory on the metabolism of the lanthanons (rare earths) entitled, "The Metabolism of the Lanthanons in the Rat," based on the summary report UCRL-3066, has been submitted for publication in Biochimica et Biophysica Acta. A summary of the experiences in this laboratory with At^{211}, "Physiological and Biochemical Studies of Astatine-211(eka-iodine)," was submitted for presentation at the Geneva Conference and will appear as UCRL-2901. A detailed description of the production and isolation of At^{211} will appear as UCRL-3065.

RADIATION CHEMISTRY

Warren M. Garrison in charge

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

DEVELOPMENT OF ANALYTICAL PROCEDURES FOR RADIATION CHEMICAL STUDIES OF AQUO-ORGANIC SYSTEMS

Radiolysis of even the simpler aquo-organic systems usually results in the formation of a spectrum of reaction products, most of which are obtained in small amounts at low concentration. Elucidation of the mechanisms resulting in their formation is often limited by the difficulties involved in the development of adequate analytical methods. In previous reports[1] we have described the application of radiometric and chromatographic techniques to the quantitative study of a number of organic products formed in the irradiation of several organic acid-water systems, e.g., formic acid, acetic acid, and glycine. A major fraction of this work involved the development of analytical methods for identification and determination of the higher-molecular-weight acids that are synthesized. It has also been shown that carbonyl compounds are important products in such systems.[1,2] Methods for the separation and determination of the carbonyl products that have been encountered are described below. The methods reported represent part of a general analytical procedure that is being developed for the determination of organic products in irradiated material. Since a major motivation for the radiation studies in this laboratory is the viewpoint that the results obtained will be of significance in the investigation of radiation biological phenomena, the development of analytical techniques has been oriented to obtain methods that will be applicable with minor changes to systems of greater complexity.

PROCEDURES FOR DETERMINATION OF CARBONYL PRODUCTS

Analytical methods have been developed for a number of lower-molecular-weight carbonyl compounds. Data have been obtained for formaldehyde, acetaldehyde, acetone glyoxal, glyoxalic acid, and mesoxalic acid. The determinations are based on the chromatographic separation of the 2,4-dinitrophenylhydrazone derivatives. In earlier studies[1] it was found that satisfactory separations of the lower aldehyde, ketone, aldehyde acid, and keto acid hydrazones can be obtained chromatographically on filter paper strips or on cellulose columns. The "nonacid" carbonyl derivatives are chromatographed with petroleum ether containing 3% methanol. The aldehyde acid and keto acid hydrazones remain at the origin under these conditions, and are subsequently separated with butanol saturated with 3% aqueous ammonia solution. The solvent sequence can be reversed if it is found desirable to remove the carbonyl acid hydrazones first. In product identification studies an aliquot of the target solution, previously treated with

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1 University of California Radiation Laboratory Reports No. UCRL-3013, 1955; UCRL-2661, and UCRL-2823, 1954.

2 W. M. Garrison, W. Bennett, S. Cole, H. R. Haymond, and B. Weeks, J. Am. Chem. Soc. 77, 2720 (1955).

platinum black to remove hydrogen peroxide, is added to a 0.1% solution of 2,4-dinitrophenylhydrazine in 2 N hydrochloric acid.[3] The hydrazones are extracted with chloroform and separated chromatographically on filter paper as described above. The strips are sprayed with 10% potassium hydroxide solution for increased sensitivity. Identification is based on a comparison of R_f values obtained for derivatives isolated from targets and for authentic 2,4-dinitrophenylhydrazones, which are cochromatographed at adjacent position.

It has subsequently been found that the filter paper technique can be extended to yield quantitative results. In this case the appropriate areas of the developed chromatogram are isolated, and the separated hydrazone derivatives are extracted quantitatively into a small volume of methanol. This is mixed with a solution of 10% potassium hydroxide in 80% methanol-20% water to produce an intensified color. The optical density is measured at the wave length of the absorption maximum. Although it has been reported[4] that the absorption maximum and the extinction coefficient are independent of the nature of the carbonyl derivative, it has been observed in this work that it is necessary to use a calibration curve for each of the carbonyl derivatives[5] studied. The percent transmission of methanolic solutions of the hydrazones of formaldehyde, acetone, and mesoxalic acid have each been found to be constant with time for a period of one hour. The hydrazones of both glyoxalic acid and acetaldehyde, however, show characteristic changes on standing under similar conditions. Typical results for the latter two derivatives are shown in Figs. 1 and 2. The quantitative results are not affected by the fading phenomena if the appropriate calibration curves are used.

A modification of the above procedures has been developed for irradiation studies in which a C^{14}-labeled target solute is used. After irradiation, milligram amounts of the appropriate carbonyl compounds are added, and the hydrazone derivatives are formed. These are then separated on a cellulose column with the same solvent sequence as described above. Yields, in this case, are based on the specific activity of the isolated hydrozone,[5] and quantitative recovery is, therefore, not required. Application of these techniques to the separation and determination of carbonyl products formed in the irradiation of formic acid solution is described in the following section.

DETERMINATION OF CARBONYL COMPOUNDS IN IRRADIATED FORMIC ACID SOLUTION

It has been shown that oxalic acid, glycolic acid, tartronic acid, tartaric acid, and the carbonyls formaldehyde, glyoxal, glyoxalic acid, and mesoxalic acid are formed in the heavy-particle irradiation of oxygen-free

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[3] H.A. Iddles and C.E. Jackson, Ind. Eng. Chem. Anal. Ed. 6, 454 (1954).

[4] G.R. Lappin and L.C. Clark, Anal. Chem. 23, 541 (1951).

[5] (a) C. R. Maxwell, D. C. Peterson, and N. E. Sharpless, Radiation Res. 1, 530 (1954); (b) W.M. Dale, J. V. Davies, and C.W. Gilbert, Biochem. J. 45, 93 (1949); (c) G. Stein and J. Weiss, J. Chem. Soc., 3256, 1949.

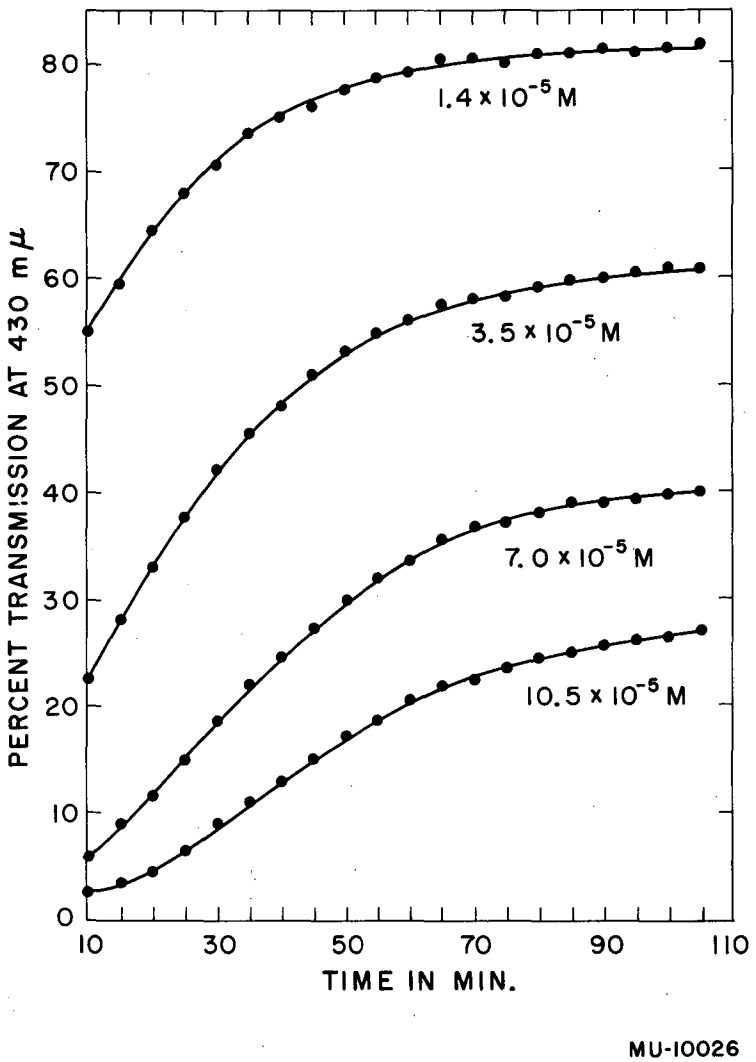


Fig. 1. Percent transmission of acetaldehyde 2, 4-dinitrophenylhydrazone in methanolic potassium hydroxide solution (after the method of Lappin and Clark, ref. 4).

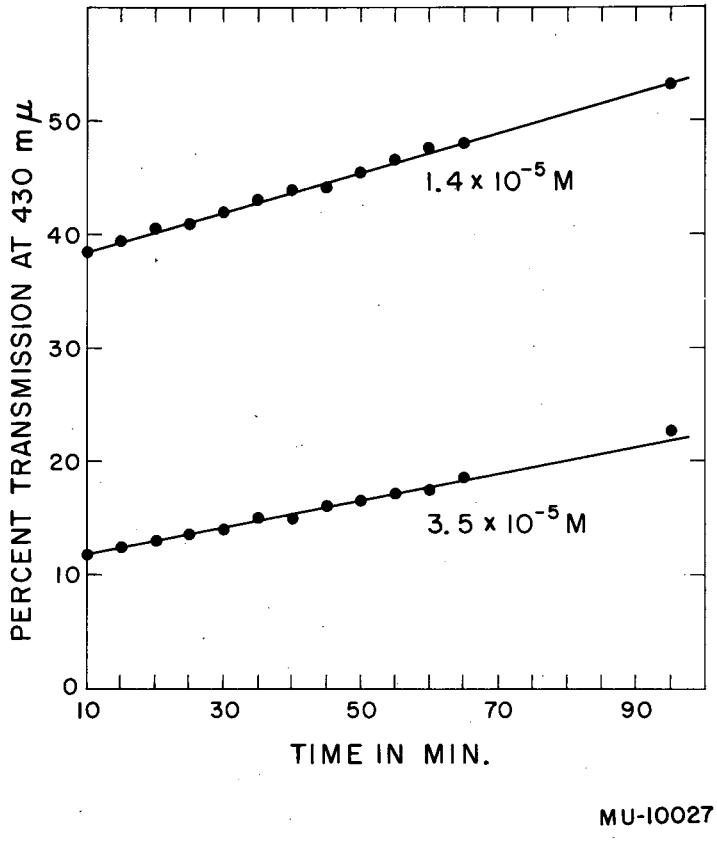


Fig. 2. Percent transmission of glyoxalic acid 2, 4-dinitrophenylhydrazone (conditions as indicated in Fig. 1).

formic acid solutions at radiation doses which result in the removal of less than 1% of the formic acid initially present in the target solution. It should be re-emphasized here that our work on such systems, which are fairly complex from a radiation chemical standpoint, is not motivated simply by a desire to identify radiation products as such. Rather, our interest in these product compounds arises primarily from the fact that such information provides a basis for ascertaining the detailed mechanism of the radiation-induced chemical reaction. From this viewpoint, it is necessary that the important organic products be not only identified but also quantitatively determined so that a material balance can be obtained. Previous reports have described quantitative analytical methods for the organic acids (Fraction I) formed in irradiated formic acid. Data for the carbonyl products (Fraction II) have been essentially qualitative. Described below is a method for the determination of both I and II in a simple sample of irradiated solution. This procedure has been found applicable, with monor changes, to radiation studies of other organic acid–water mixtures. Data are now being obtained for the formic acid system.

The irradiated formic acid solution containing $HC^{14}OOH$ is treated with (a) platinum black to remove hydrogen peroxide, and (b) measured milligram amounts of carrier for each of the products in Fractions I and II. The solution is then equilibrated with an appropriate volume of "carbonyl-free" ether saturated with 2,4-dinitrophenylhydrazine. The ether is removed by evaporation, and any precipitate is filtered off. This fraction (IIA) contains essentially all the glyoxal and most of the formaldehyde as the hydrazone derivative, together with some of the excess hydrazine reagent. The filtered target solution is then passed through a Dowex-50 column which removes all of the remaining hydrazine reagent and dissolved hydrazones with the exception of the mesoxalic acid derivative. The latter is collected in the effluent with the formic acid and the product-carrier acids (I). The effluent is evaporated to dryness in vacuo to remove the formic acid solute. The residue is chromatographed on a silicic acid column to separate the organic acid Fraction I into its components. Yields are determined from the measured activity for each acid. The mesoxalic acid hydrazone is recovered as a separated acid fraction (IIB).

The hydrazones and reagent removed by the Dowex-50 column are eluted with carbonyl-free methanol. This fraction (IIC) contains principally glyoxalic acid hydrazone. Each of the separated hydrazone fractions (IIA, IIB, and IIC) is then chromatographed on a cellulose column as described in the previous section. Corresponding bands in each fraction are combined, and these are rechromatographed to give samples of separated hydrazone for specific-activity measurements.

GLYCINE RADIOLYSIS

Radiation yields of the major decomposition products formed in the heavy-particle irradiation of oxygen-free glycine solutions have been discussed in previous reports. The products of indirect action include hydrogen, ammonia, glyoxalic acid, formic acid, and acetic acid. Methylamine, formaldehyde, and carbon dioxide, also formed in the radiolysis, are attributed to direct action. Recent studies of dilute glycine solutions containing $NH_2CH_2C^{14}OOH$ have shown that succinic acid, amino succinic acid, and diamino succinic acid are also formed in low yield. Identification

is based on the correspondence between C^{14}-labeled product activity and titre of added authentic acids as observed in the cochromatographs shown in Figs. 3 and 4. Details of the experimental techniques employed in the isolation and identification of these products will be presented in a later report.

The main point of interest here is that, although the observed radiation yield for each of the higher molecular weight organic acids is less than 0.05, formation of these products (even in minimal amounts) provides evidence for the free-radical intermediates, CH_2COOH and $NH_2CHCOOH$.

In a summary report on glycine radiolysis now in preparation, it is shown that data obtained in this laboratory for heavy-particle radiation, and those reported elsewhere[5] for X- and γ-rays in both evacuated and oxygen-saturated systems, can be interpreted on the basis of the following series of reactions:

Primary radiation processes

$$H_2O \xrightarrow{\sim\sim} H + OH, \quad (1)$$

$$2\ H_2O \xrightarrow{\sim\sim} H_2 + H_2O_2 \quad (2)$$

Secondary processes

Oxygen absent

$$H + NH_2CH_2COOH \longrightarrow NH_3 + CH_2COOH, \quad (3)$$

$$\longrightarrow H_2 + NH_2CHCOOH, \quad (4)$$

$$OH + NH_2CH_2COOH \longrightarrow H_2O + NH_2CHCOOH, \quad (5)$$

$$CH_2COOH + NH_2CH_2COOH \longrightarrow CH_3COOH + NH_2CHCOOH, \quad (6)$$

$$CH_2COOH + NH_2CHCOOH \longrightarrow COOHCH_2CH(NH_2)COOH, \quad (7)$$

$$2\ CH_2COOH \longrightarrow COOHCH_2CH_2COOH, \quad (8)$$

$$2\ NH_2CHCOOH \longrightarrow NH_2CH_2COOH + NHCHCOOH \quad (9)$$

$$\longrightarrow COOHCH(NH_2)CH(NH_2)COOH, \quad (9a)$$

$$NH_2CHCOOH + H_2O_2 \longrightarrow H_2O + OH + NHCHCOOH, \quad (10)$$

$$NHCHCOOH + H_2O \longrightarrow NH_3 + CHOCOOH. \quad (11)$$

Oxygen present

$$H + O_2 \longrightarrow HO_2, \quad (12)$$

$$OH + NH_2CH_2COOH \longrightarrow NH_2CHCOOH + H_2O, \quad (5)$$

$$NH_2CHCOOH + O_2 \longrightarrow NHCHCOOH + HO_2, \quad (13)$$

$$NHCHCOOH + H_2O \longrightarrow NH_3 + CHOCOOH, \quad (11)$$

$$2\ HO_2 \longrightarrow H_2O_2 + O_2. \quad (14)$$

Evidence for each of the above reactions and their relative importance in heavy-particle and γ-ray irradiations will be discussed in detail in the summary report UCRL-3071

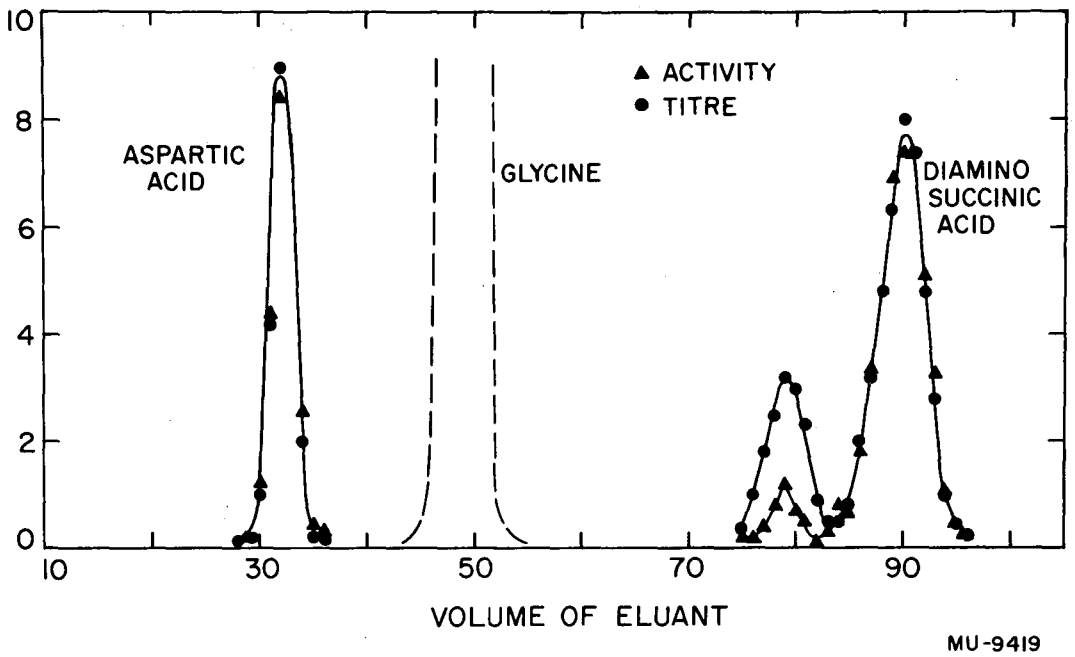


Fig. 3. Identification of aspartic and diamino succinic acids.

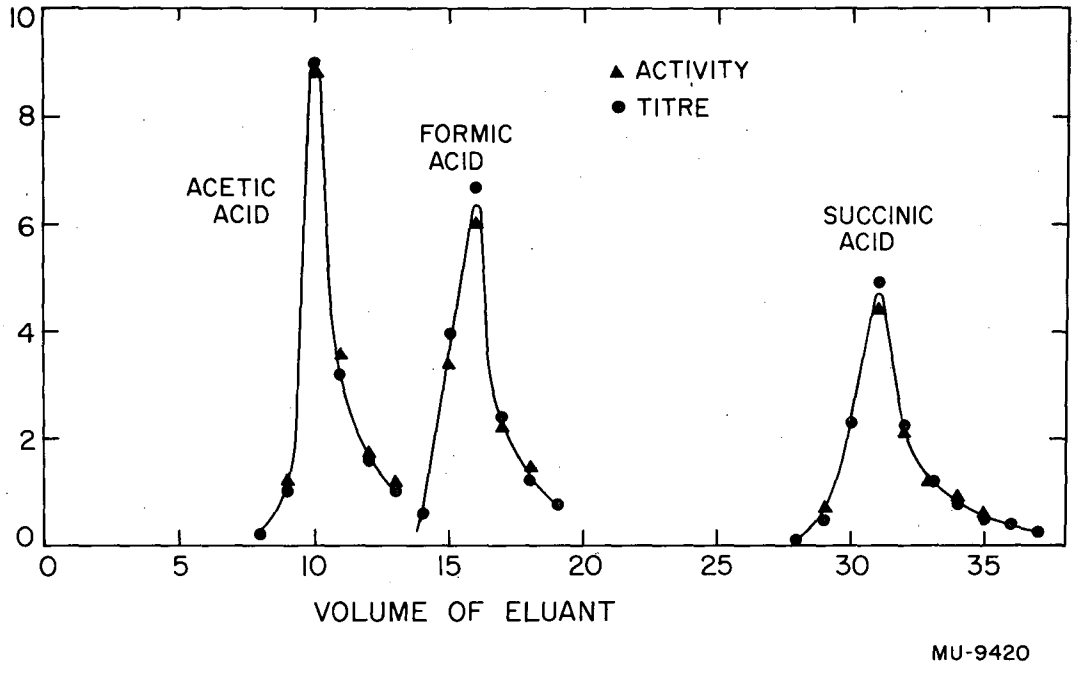


Fig. 4. Identification of succinic acid.

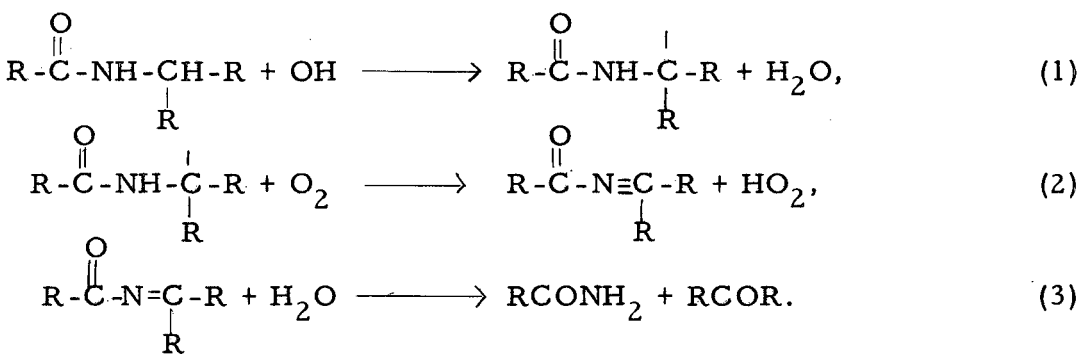
PROPOSED MECHANISM FOR A RADIATION-INDUCED DECOMPOSITION OF THE PEPTIDE CHAIN

In the previous section it has been proposed that the major products (NH_3 and CHOCOOH) from irradiated glycine solution containing oxygen can be accounted for on the assumption that iminoacetic acid is formed as an intermediate, i.e.,

$$\cdot OH + NH_2CH_2COOH \longrightarrow NH_2CHCOOH + H_2O,$$
$$O_2 + NH_2CHCOOH \longrightarrow NHCHCOOH + HO_2,$$
$$NHCHCOOH + H_2O \longrightarrow NH_3 + CHOCOOH,$$
$$2\,HO_2 \longrightarrow H_2O_2 + O_2.$$

Consideration of the above reactions has led to the conclusion that rupture of other N-C bonds may occur via a similar mechanism. Of particular interest is the possible significance of this reaction in the radiation chemistry of polypeptides. In this case, the following reactions may be proposed where (I) represents the peptide:

(I)



(1)

(2)

(3)

What is considered to be the important point here is that the above radiation-induced reaction would result in the formation of an amide and a carbonyl terminal group, whereas the acid- and (or) base-catalyzed decomposition of protein form the carboxyl and amino groups. It is also of significance that Reaction (3) and also the hydrolysis of the amide formed via (3) would provide a specific mechanism for observed postirradiation effects in protein systems. Experimental work has been initiated to test these hypotheses. Protein and a number of simple organic compounds containing the N-C linkage are being studied. In his latter group are included the N-methyl-substituted amides and the primary and secondary amines.

CHEMICAL ACTINOMETRY OF CYCLOTRON RADIATIONS

The aqueous formic acid–oxygen actinometer developed by Hart[6] is being used in this laboratory (a) to provide an independent check of the reproducibility of cyclotron beam monitoring, (b) to determine the maximum beam intensities at which all H and OH radicals formed in water can be measured, and (c) to measure for cyclotron radiations the G values of the radical and forward reactions in water. Carbon dioxide evolution from the

[6] E. J. Hard, Radiation Res. 1, 53 (1954).

irradiated formic acid solution provides a measure of the radical reaction, whereas hydrogen peroxide is produced as a consequence of both processes. It has been shown[6] from an interpretation of the mechanism in dilute formic acid solution that the radical- and forward-reaction yields represented by G_1 and G_2 respectively are given by: $G_1 = G_{CO_2}$, $G_1 + 0.5\, G_2 = G_{H_2O_2}$. Hydrogen peroxide formation in 0.05 N formic acid solution irradiated with 35-Mev helium ions at a beam intensity of 0.010 μa are shown in Fig. 5. All-glass target cells of a type previously described were used in this study. The solutions were aerated with oxygen or with a 20% oxygen-80% helium mixture during irradiation. Peroxide yields in each case are proportional to dose over the range studied. The highest dose value corresponds to 7×10^{18} ev/cc. Mechanical stirring has no effect on peroxide yields at the beam intensity employed. Hydrogen peroxide yields calculated from the slope of each curve and extrapolated to infinite oxygen concentration give $G_{H_2O} = 2.45$. Similar experiments in which $HC^{14}OOH$ was added to the 0.05 N formic acid target solution have been made. In this case the effluent gas was passed through a series of traps filled with 0.1 N sodium hydroxide solution. Data on the radical yield G, as measured by the CO^{14}_2 production, will be presented in later reports.

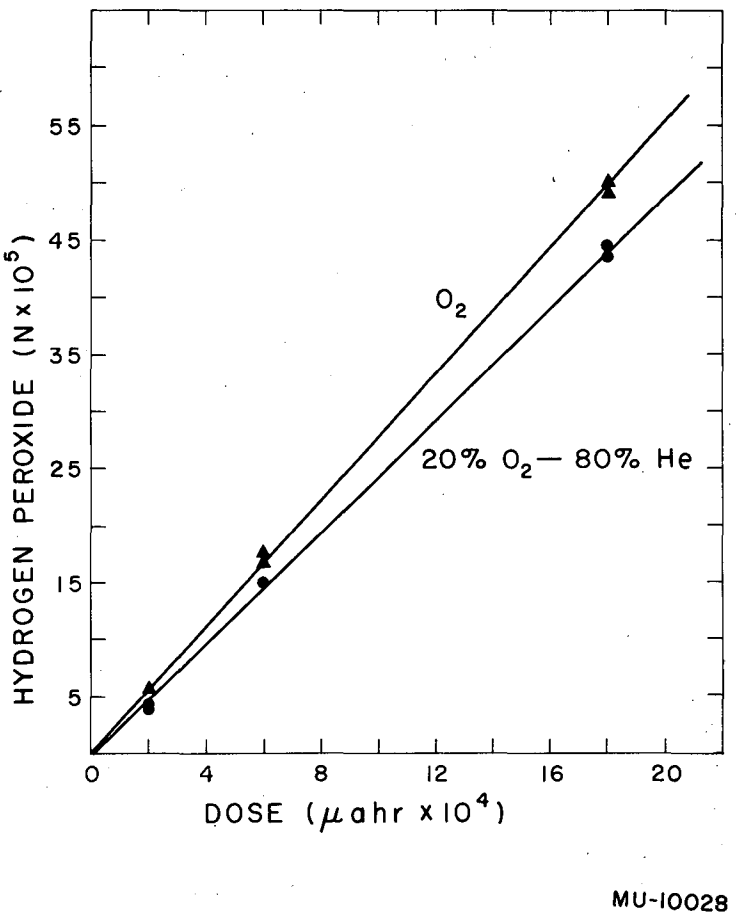


Fig. 5. Hydrogen peroxide production in formic acid–oxygen solutions.

BIOLOGICAL STUDIES OF RADIATION EFFECTS

John H. Lawrence, M. D., in charge

Donner Laboratory of Biophysics and Medical Physics
University of California, Berkeley, California

MERCAPTOETHYLAMINE AND LIVER SHIELDING IN IRRADIATED RATS; STUDY OF ERYTHROPOIESIS WITH IRON-59

H. Maisin and Raymond G. Wolfe

The availability of the new drug mercaptoethylamine (MEA), which is a sulfhydryl compound as well as a fragment of the important coenzyme A, prompted a study of its influence on the effects of radiation.

The ability of this substance to modify the effects of radiation when administered before irradiation, after irradiation, or with or without shielding of the liver region was studied in two ways. The 28-day survival was observed, and the erythropoiesis was studied using Fe^{59}.

The 28-day survival study showed that MEA administered after irradiation does not modify the effects of radiation. MEA administered before irradiation has a protective effect which is additive with that afforded by lead shielding of the liver region. Control animals receiving 850 r of x radiation (180 kv) all die within 5 days. Animals receiving MEA before radiation survive to the extent of 10% after 28 days. Rats having the liver region shielded during irradiation survive to the extent of 45% after 28 days. Animals having liver shielded and MEA administered before radiation survive to the extent of 80% after 28 days.

The influence of radiation by 500 r of x-rays on the kinetics of Fe^{59} in a number of tissues was studied. Moreover, the ability of lead shielding of the liver region and the administration of MEA before irradiation to modify the typical kinetic pattern of Fe^{59} in irradiated animals was investigated. MEA was able to promote delayed regeneration of red blood cell formation in irradiated rats, as shown by increased Fe^{59} uptake. An earlier regeneration of erythropoiesis was observed in animals in which the liver region was shielded during radiation. The influence of MEA in regeneration of erythropoiesis seems to be restricted to doses below 500 r.

RADIATION HYPOPHYSECTOMY AND RELATED STUDIES USING 190-Mev DEUTERONS AND 340-Mev PROTONS*†

Cornelius A. Tobias, James F. Roberts, John H. Lawrence, Hal O. Anger, B. V. Low-Beer, Graeme P. Welch, and James L. Born

The deflected monoenergetic particles from the 184-inch cyclotron in Berkeley promise to be of manifold usefulness in the field of radiobiological research and therapeutic investigation. A small, well-defined beam of protons or deuterons can be passed through biological tissue without appreciable spreading of the ionization due to scattering; by use of this property and the well-known rotational technique considerable internal doses can be delivered without causing appreciable damage to intervening and neighboring tissues. In addition, the particles may be made to stop at any well-defined depth in tissue. The beam passes through the Bragg ionization peak just before stopping.[1] Over the past several years the biological effectiveness of the above radiations has been evaluated[2] by using microorganisms[3] and animal lethality studies. Several radiobiological studies were completed on the effect of partial-body irradiations of animals,[4,5] including tumor therapy studies.

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* Abstract submitted for Geneva Conference, August 1955; UCRL-2907 (Abstract)

† The major part of this study was supported by the AEC. The authors gratefully acknowledge additional support from the State of California Cancer Grant and the Donner Foundation. Several phases of the work abstracted here were carried out in collaboration with different individuals and institutions. Among these are: Institute of Experimental Biology and Medicine, University of California; Dept. of Ophthalmology, Columbia University; Dept. of Pediatrics, Yale University; the Ben May Laboratories, University of Chicago.

1 Cornelius A. Tobias, Hal O. Anger, and John H. Lawrence, Radiological Use of High-Energy Deuterons and Alpha Particles, Am. J. Roentgenol., Radium Therapy and Nuclear Med. LXVII, No. 1, 1-27 (January, 1952).

2 Norman H. Giles and C. A. Tobias, Effect of Linear Energy Transfer on Radiation-Induced Chromosome Aberrations in Tradescantia Microspores, Science 120, 993-994 (December 10, 1954).

3 Raymond E. Zirkle and Cornelius A. Tobias, Effects of Ploidy and Linear Energy Transfer on Radiobiological Survival Curves, Arch. Biochem. and Biophys. 47, 282-306 (December, 1953).

4 Ludwig Von Sallmann, and Cornelius Tobias, The Effects of High-Energy Alpha Particles and Deuterons on the Rabbit Lens (in press).

5 C. A. Tobias, D. C. Van Dyke, M. E. Simpson, H. O. Anger, R. L. Huff, and A. A. Koneff, Irradiation of the Pituitary of the Rat with High-Energy Deuterons, Am. J. of Roentgenol. Radium Therapy and Nuclear Med. LXXII, No. 1, 1-21 (July, 1954).

Radiation hypophysectomies were carried out in the rat,[5] dog, and monkey. Large doses to the pituitary caused a marked decrease of hypophyseal function in each of these species, as evidenced by atrophy of the pituitary and of the target organs, by decreased I^{131} uptake, and by decreased growth. The radiation effects are delayed, and with higher dose the onset is more rapid. Localized irradiation of small hypothalamic loci in the rat lead to imbalances in hypothalamic control of hypophyseal function. Growth, thyroid function, water and fat metabolism have been thus affected.

Eight patients received proton pituitary therapy. Each had widespread and progressing metastatic cancer secondary to cancer of the breast. They had all previously received conventional forms of therapy, including mastectomy, x-radiation, hormonal therapy, oophorectomy and adrenalectomy. Rationale for this kind of therapeutic investigation is the strong influence of hormonal substances on certain carcinomas and the reported regressions and remissions after removal of testes, ovaries, and adrenals. Surgical hypophysectomies performed over the past three years indicate strong relationship of hypophyseal function to cancer. Evidence is available showing delayed depression of pituitary activity following pituitary proton therapy, particularly depression of thyroid function as indicated by I^{131} turnover, pituitary gonadotropins, shifts in carbohydrate metabolism, serum phosphatase levels, calcium excretion, and estrogen levels. Complete evaluation of the possible favorable effects on cancer will take several more years.

The proton and deuteron beams of the cyclotron appear to be useful not only in therapeutic investigations where partial or complete hypophysectomy is desired but also they may help to increase the storehouse of knowledge regarding the homeostatic control mechanisms of the hypothalamus, and, more generally, in mapping of the functional regions of the brain.

THE INFLUENCE OF PLOIDY AND DIVISION STAGE ON THE ANOXIC PROTECTION OF SACCHAROMYCES CEREVISIAE AGAINST X-RAY INACTIVATION

Carl A. Beam

It has been shown that for the lethal effect of x-rays on haploid yeast the dose is effectively halved for cells irradiated in the absence of oxygen.[1] The knowledge that in yeast the onset of budding is accompanied by a great decrease in sensitivity to the lethal action of x-rays[2] and alpha particles[3] raises the question of internal protection at this time, possibly of the same sort as that conferred by externally imposed anoxia. If this were the case, one would expect anoxia to provide little or no protection to cells in the process of budding. The additivity experiments to be reported here accordingly employed cells from actively growing cultures to insure the presence of adequate percentages of budding cells.

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1 A. C. Birge and C. A. Tobias, Arch. Biochem. and Biophys. 52, 388-393 (1954).

2 C. A. Beam, R. K. Mortimer, R. G. Wolfe, and C. A. Tobias, Arch. Biochem. and Biophys. 49, 110-122. (1954).

3 M. M. Elkind and C. A. Beam, Rad. Res. (in press).

In addition to the standard haploid strain of Saccharomyces cerevisiae (Sc-7), the parental diploid (Sc-6) and a derived tetraploid (X-33)[4] were studied. All cultures were grown aerobically at 30° on yeast extract glucose agar, harvested for experiments after 12 to 18 hours' growth, and spread on petri dishes containing this medium for irradiation and postirradiation aerobic incubation (3 days at 30°). Survival ratios were obtained by comparing colony counts of irradiated plates to those of unirradiated controls.

Detailed accounts have been given, both of the radiation source used--a low-voltage x-ray tube (Machlett OEG-60) operated at 50 kv and 25 ma,[4]--and of the procedures employed in handling the yeast cells.[2] The chamber used to maintain a nitrogen atmosphere for anoxic irradiations is shown in Fig. 1. Tank nitrogen under reduced pressure flows in one tube, through the chamber, and out the other, at which the rate of flow can be checked by watching the bubbles rising in the beaker. The nitrogen is confined by the rubber gasket between the petri dish and the collar and by the cellophane window. Control tests have shown that (a) a nitrogen atmosphere does not affect the survival of unirradiated yeast, (b) the cellophane window is sufficiently thin to be transparent to x-rays, (c) one-minute flushing of each sample with nitrogen prior to irradiation is sufficient to ensure maximum protection, i.e. the twofold dose reduction previously obtained[1] when using much more meticulous instrumentation. A preirradiation flushing of two minutes was routinely employed in the experiments described in the following.

Figure 2 shows representative survival curves of haploid yeast irradiated in the presence and in the absence of oxygen. Both curves show the compound character which has been shown[2] to typify the survival of cells from growing cultures. The initial exponential, representing the survival of interdivisional cells, is followed by a multiple-hit component or "tail," which represents the survival of cells in the process of budding.[2] It can be seen that within experimental error an approximately twofold protection is afforded by nitrogen throughout the observed range of survivals.

Figures 3 and 4 show the results of similar experiments on diploid and tetraploid yeast respectively. As for the haploid, these curves show "tail" components at survival levels in agreement with the percentage of budding cells in the populations treated. Further, a dose-reduction factor of about two relates the anoxic curves to the aerobic ones throughout their observed length.

Three major conclusions can be drawn from the above results. Firstly, the x-ray survival curves of yeast of all ploidies treated show radioresistant tail components corresponding in level of inception to the percentage of budding cells in the population, and therefore, as has been shown rigorously[2] for the haploid strain, probably representing the survival of this population moiety. Moreover, when the LD^{10}'s of the diploid and tetraploid tails are compared with that of the haploid, as is done in Table I, it can be seen that the values for diploid and tetraploid cells fall within the range of variation obtained from different experiments with the haploid. Although ploidy is an important determinant of the radiosensitivity of interdivisional cells, as has been shown by many investigators and as can be seen in the early parts of the above curves, the radioresistance conferred by the onset of cell division appears to be independent of this factor.

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[4] R. K. Mortimer, Medical and Health Physics Quarterly Report for April, May, June 1952, University of California Radiation Laboratory Report No. UCRL-1922
Lawrence

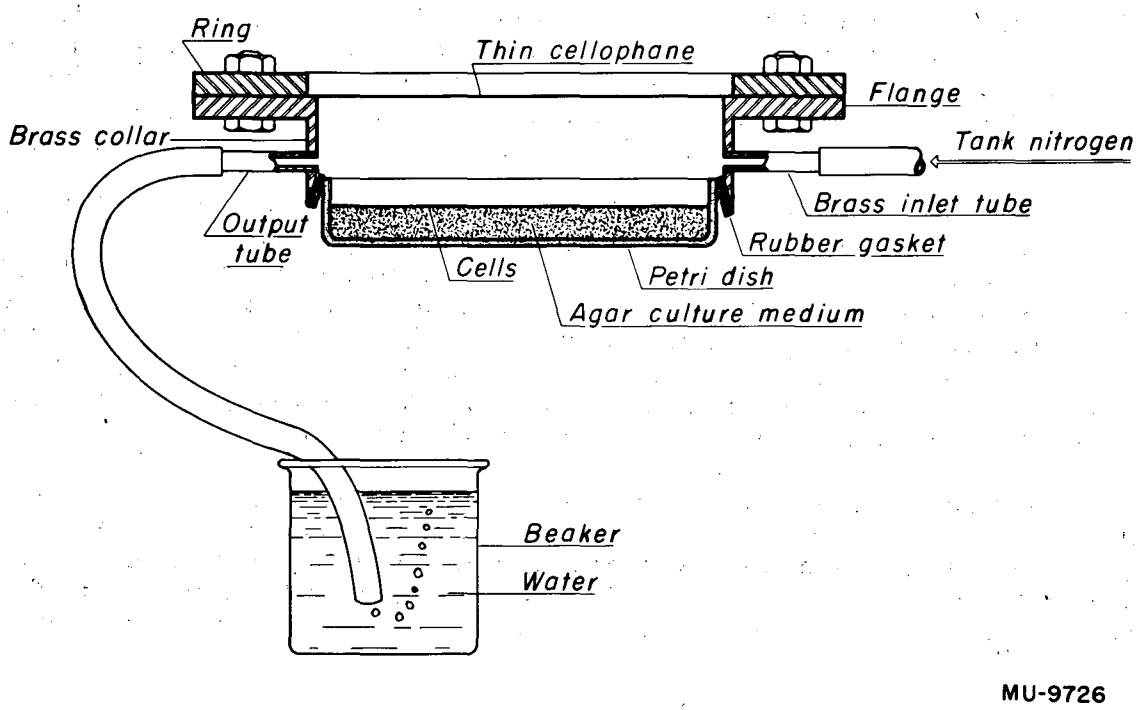

Fig. 1. The chamber employed in anoxic x-ray exposures.

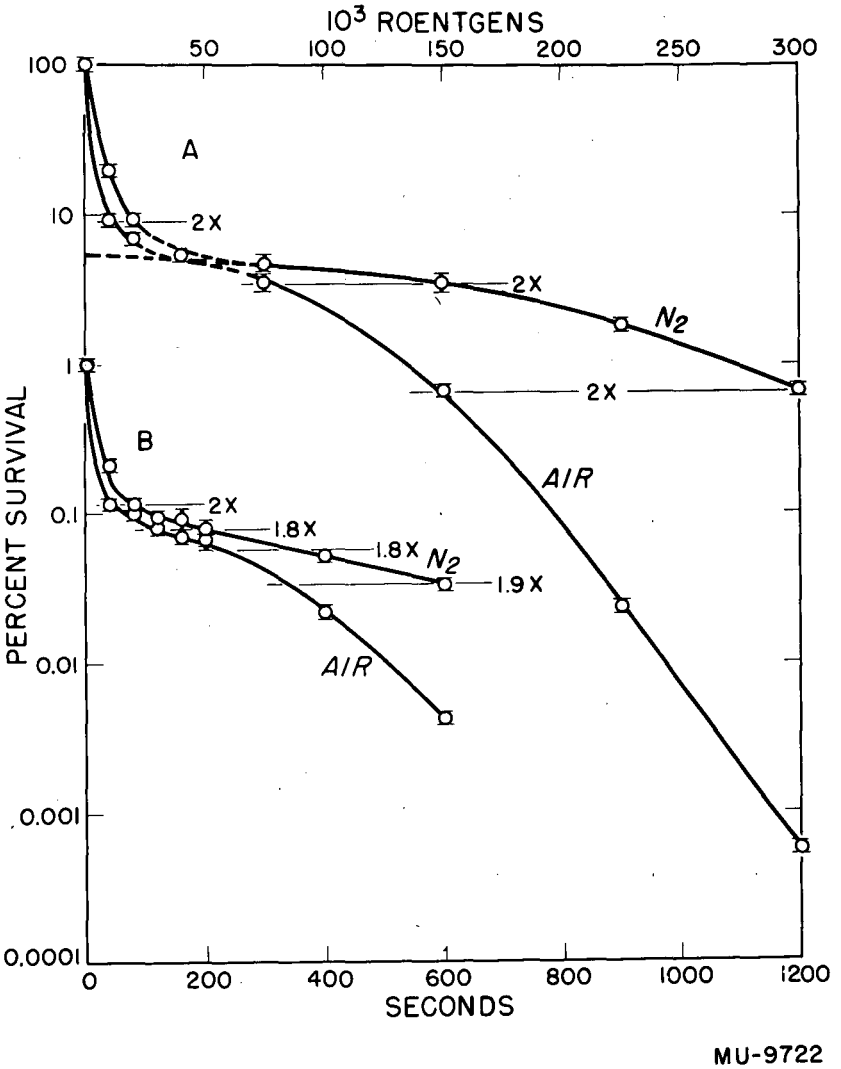

Fig. 2. Aerobic and anoxic survival curves of haploid yeast. A and B represent separate experiments; B is plotted from the 1% survival level only for convenience. The errors indicated represent standard deviations of the means. Numbers to the right of curves indicate dose-reduction values taken from the curves at the indicated survival levels. Dotted portions represent back extrapolates of the tail portions.

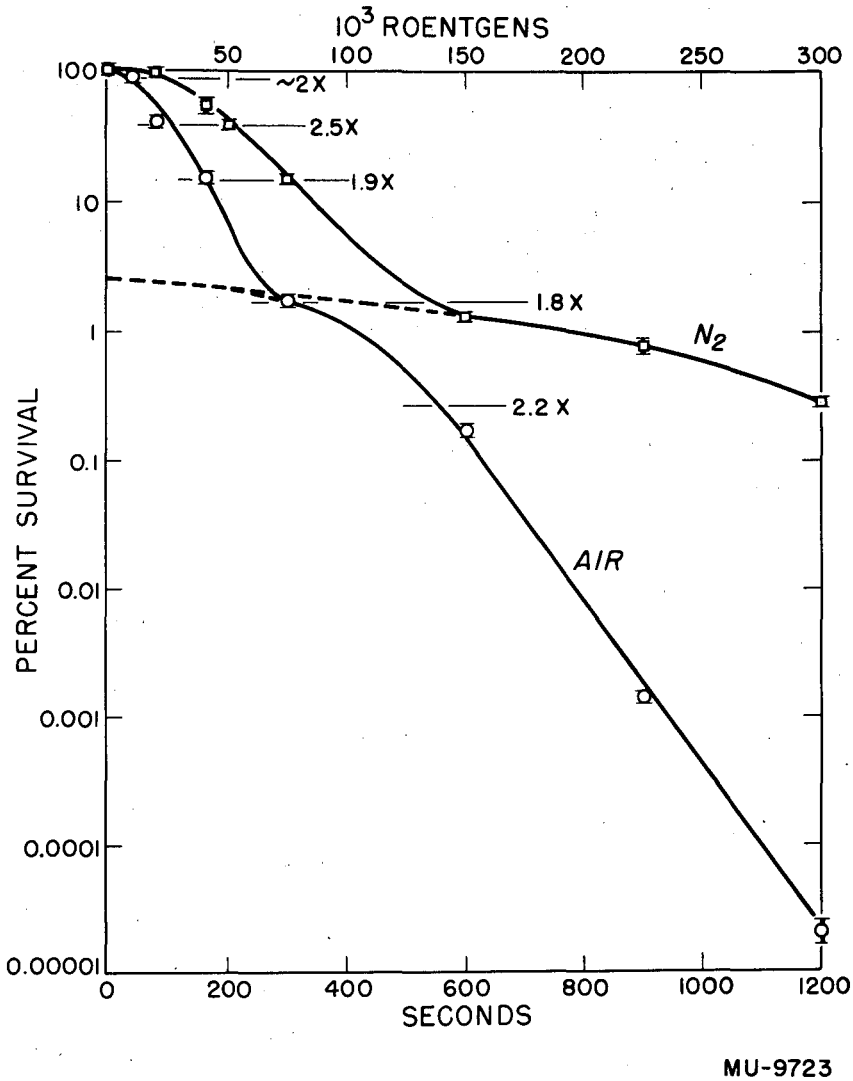

Fig. 3. Aerobic and anoxic survival curves of diploid yeast.

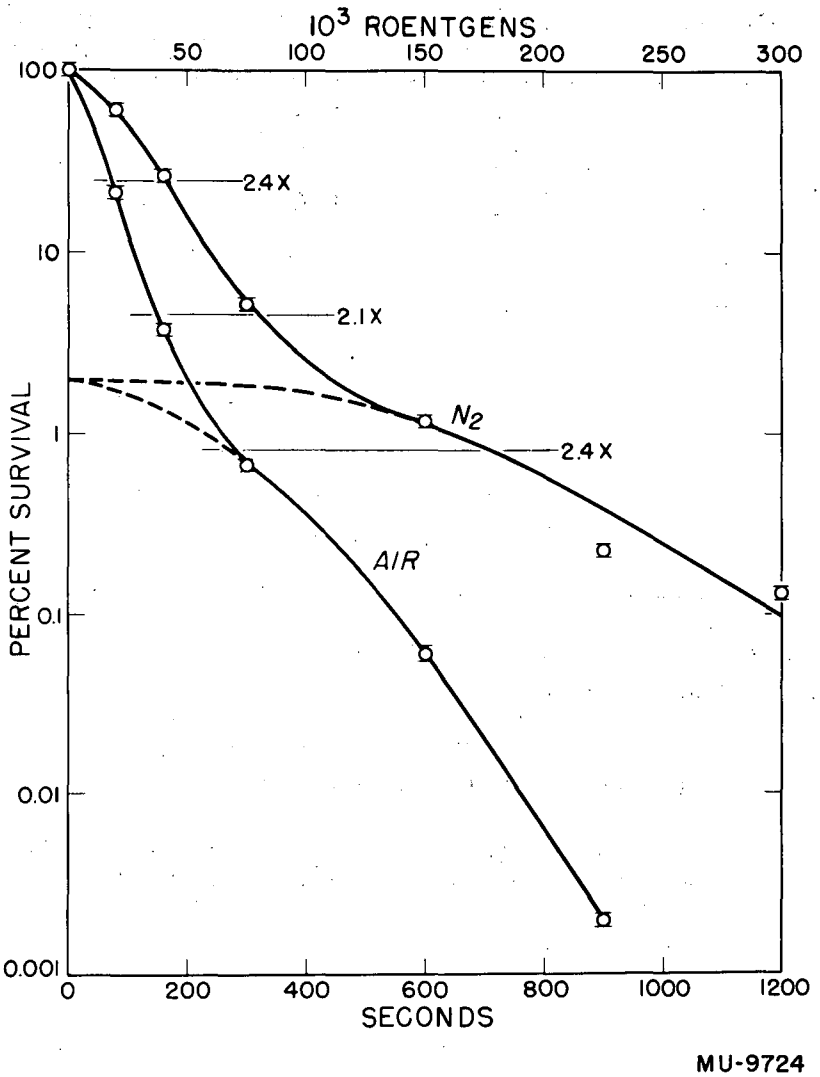

Fig. 4. Aerobic and anoxic survival curves of tetraploid yeast.

Table I

Sensitivity data compiled from several aerobic and anoxic experiments with yeast of different ploidy.

Experiment	Ploidy	Dose rate, r/sec	Air		Nitrogen
			LD_{10}(Tail)[2] x 10^3r	Slope of tail asymptote[3] (LD_{10}x10^3r)	LD_{10}(tail) x 10^3 r
1	n	252	122		
2	n	252	106		
3	n	252	156	46	318
4a[1]	n	252	116		
4b	n	920	111	55	
5	n	252	147	38	
6a	4n	252	116	50.4	252
6b	4n	920	100	30.3	
7a	2n	252	146	38	307
7b	2n	920	144	43	

1 a and b notation signifies parallel experiments done with the same material at the same time

2 Dose requisite to produce 10% survival, in this case taken from the zero dose intercept of the tail extrapolate

3 Dose requisite for 10% drop in survival on the asymptotic exponential portions of the tail regions of the survival curves

Secondly, the fact that anoxia provides the same protection to dividing cells as to interdivisional ones eliminates anoxia as the source of the high resistance of cells in the process of budding. If this high resistance arises through a protective mechanism rather than through changes in "target" material, it is by chains of events other than those involved in anoxic protection.

A third point relates to current evidence concerning the nature of the lethal x-ray damage in yeast. The production of both recessive[5] and dominant[6] lethal damage by x-rays has been demonstrated, and it has been shown that the x-ray survival curves of related strains of different ploidy can best be fitted if these two effects are induced in a ratio of about 15:1 per genome.[4] Thus, whereas haploid cells would be killed largely by recessive lethals, the role of dominant lethals would increase with increasing ploidy to the extent that tetraploid cells would be inactivated almost exclusively by the latter effect. In these terms the above experiments show that the frequencies of recessive lethal damage (killing of interdivisional haploids), dominant lethal damage (killing of tetraploids*), and whatever combination of these and other effects inactivates dividing cells of all ploidies are reduced to the same extent by anoxia. These results can be considered to support the widely held view that the role of oxygen in x-ray damage more probably lies in determining the nature or concentration of free radicals formed in early radiochemical events than in differentially affecting the cell's relative sensitivity to different terminal biological changes.

Summary

The lethal effect of x-rays administered in the presence and absence of oxygen has been compared in dividing and interdivisional cells of haploid, diploid, and tetraploid strains of Saccharomyces cerevisiae. An approximately twofold dose reduction was effected by anoxia in all instances. Considered in terms of the evidence for different modes of lethal action in these different systems, these findings favor the involvement of oxygen in early radiochemical events rather than in terminal biological changes.

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[5] R. K. Mortimer and C. A. Tobias, Sci. 118, 517-518 (1953).

* Direct evidence of a twofold anoxic protection against dominant lethal damage has been reported[6] for yeast.

[6] R. K. Mortimer, Rad. Res. 2, 361-368(1955).

EFFECTS OF HIGH-ENERGY ALPHA PARTICLES, DEUTERONS, X-RAYS, AND AGING ON MAMMALIAN LENS EPITHELIUM*

L. von Sallmann, C. A. Tobias, H. O. Anger, G. Welch, S. F. Kimura, C. M. Munoz, and A. Drungis

The poorly understood process of cataract formation has been studied by the irradiation of rabbit eyes and followed by the visual and microscopic observation of the changes induced, as a function of time and dose. Studies on the nature of formation of radiation-induced cataracts under controlled conditions may be helpful in understanding the more general phenomenon of cataract formation as it appears in senescence.

The fact that the cyclotron produces monoenergetic radiations with relatively low scattering makes it an ideal tool for such studies. Moreover, the energy of the radiation from the cyclotron is easily changed, making it possible to study the relative biological effectiveness of the radiations having different energies. The differences observed in the efficiency of the radiations of various energies in producing biological effects is poorly understood, and observations of the influence of radiation energy on the unique biological manifestation, the formation of cataracts, may shed new light on this problem.

By the use of appropriately shaped absorbers, the shape of the cyclotron beam was controlled to irradiate either the center of the lens or the peripheral ring of the lens. This study confirmed previous impressions of relatively high radiosensitivity of the germinative zone at the lens periphery in comparison to the relatively high radioresistence of the central area of the lens.

The studies of the influence of the energy of the radiation (comparing more densely ionizing alpha particles or deuterons with less densely ionizing x-rays) showed that there were no significant differences in the two types of radiation on cell division, but injury produced by the same doses of high-energy (densely ionizing) radiation greatly exceeded that by x-radiation. The damaging efficiency (relative biological effectiveness) of alpha and deuteron irradiation was about four times that of 210-kv x-rays.

Cytopathological changes in the lens resulting from radiation or old age were observed to be strikingly similar.

(This work was carried out in collaboration between Dr. von Sallman, The Radiological Research Laboratory, the Department of Ophthalmology, Columbia University, College of Physicians and Surgeons and The Institute of Ophthalmology, Presbyterian Hospital and the staff of Donner Laboratory of Biophysics and Medical Physics of the University of California. Dr. von Sallman spent two summers in Berkeley. This work was carried out under a contract with the AEC and the participating Universities, and was also supported by the Knapp Memorial Foundation.)

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* Submitted to the American Journal of Opthalmology for publication in the open literature.

THE INCORPORATION OF PHOSPHORUS-32 INTO DNA OF NORMAL AND IRRADIATED EHRLICH ASCITES CELLS

Lola S. Kelly and J. Dorothy Hirsch

An Ehrlich ascites tumor study has been undertaken in the hope that this material would be suitable for a quantitative correlation of the rate of DNA renewal, the rate of cell division, and the growth rate. It is generally agreed that isotopes are incorporated into DNA only at the time when cells are doubling their content of DNA in preparation for division. However, a number of papers in recent years have suggested that the rate of DNA renewal is twice the rate of cell renewal. This would imply that both daughter cells would contain only newly formed DNA.

The experiments were carried out in the following way. Groups of 35 to 40 mice were inoculated with 20 x 10^6 Ehrlich cells. On each of three days (4, 5, 6) the total number of tumor cells in groups of six randomly selected mice was measured in order to calculate the rate of increase of cell numbers at the point of the growth cycle when the DNA measurements were to be carried out. The number of tumor cells was determined by conventional hemocytometer counts combined with a measurement of the total ascites volume. This was conveniently carried out by the intraperitoneal injection of RISA (radioiodinated serum albumin), which was allowed to mix with the ascitic fluid for four minutes. At the end of this period duplicate samples of ascitic fluid were counted in a crystal counter and the total volume was calculated from the dilution of the RISA.

The remainder of the mice were injected with P^{32} on day 5 and sacrificed at 2, 4, and 6 hours. The specific activities of the inorganic phosphate, organic acid-soluble phosphate, and DNA phosphate of the ascites cells were determined in order to calculate the rate of DNA renewal.

To date the results have been disappointing. It can be stated definitely that the rate of increase of cell numbers and the rate of DNA renewal have the same order of magnitude. However, the data are sufficiently variable that it has been impossible to determine whether the two are equal or whether the rate of DNA renewal is twice the rate of cell increase.

Preliminary experiments on the influence of x-irradiation on the incorporation of P^{32} into DNA of the Ehrlich ascites tumors have been carried out. In contrast to most other mammalian tissues, the ascites tumors have a uniform cell population, which should facilitate the interpretation of biochemical changes found after irradiation (Kelly et al., Medical and Health Physics Quarterly, University of California Radiation Laboratory Report No. UCRL-2661, July 1954).

The two-hour incorporation of P^{32} into DNA, inorganic phosphate, and acid-soluble organic phosphate, was measured at various times after 800r total-body irradiation. The mice were irradiated six days after transplantation of the tumor, and P^{32} was injected 15 minutes, 2 hours, 5 hours, or 24 hours after irradiation. The data are presented in Table II and show no significant effect of irradiation on the incorporation of P^{32} into DNA within the first 5 to 7 hours. However, when the incorporation was measured (in a second.

experiment) 24 hours after irradiation, there was a marked depression.

These results, although merely preliminary, suggest that under conditions where there is no change in cell population and probably little if any outright cell death, no change in the DNA specific activities occurs.

Table II

Specific activities* of irradiated Ehrlich ascites tumor

	DNA	DNA as % INORGANIC PHOSPHATE
Experiment 1		
Controls	65.7 ± 11	0.844 ± 0.15
15 mins** after 800r	82.6 ± 27	0.986 ± 0.17
2 hours after 800r	51.3 ± 14	0.793 ± 0.13
5 hours after 800r	69.3 ± 12	0.807 ± 0.18
Experiment 2***		
Controls	118 ± 37	1.74 ± 0.35
24 hours after 800r	56.3 ± 1.2	0.815 ± 0.087

* Specific activities are expressed as counts per minute per mg phosphorus divided by the counts injected per g mouse. All values were multiplied by 10^3.

** Time from midpoint of irradiation to injection of P^{32}.

*** Experiments 1 and 2 not directly comparable because two different strains of mice used.

THE INFLUENCE OF FASTING ON THE INCORPORATION OF PHOSPHORUS-32 INTO DNA

Lola S. Kelly and J. Dorothy Hirsch

Since it has been reported (Bullough, Brit. J. Cancer 3, 275, 1949) that fasting or restricted food intake markedly reduced the mouse epidermal mitosis rate, it seemed of interest to investigate whether a similar effect could be found on the incorporation of P^{32} into DNA of various mouse tissues. If the effect were large, it would be important in the interpretation of experiments in which animals did not maintain their normal food intake -- such as irradiation, toxic drug treatments, or hypophysectomy-- and might necessitate pair-fed controls.

In a preliminary experiment the 2-hour incorporation of P^{32} into DNA of several normal tissues was compared in fed and 24-hour-fasted mice. As is evident from Table III, the DNA from all the tissues of fasted mice had a lower specific activity. The experiment was repeated with mice bearing a transplanted mammary carcinoma, and these data also are presented in Table III. In contrast to the normal tissues, the incorporation of P^{32} into DNA of the mammary carcinoma was not affected by a 24-hour fast. However, the weight of the tumors was considerably lower; controls: 1.95 ± 0.18 g; fasted: 1.24 ± 0.05 g. These results imply an arrest in tumor growth despite no apparent interference with the rate of cell renewal. It would be interesting to know whether this is a characteristic response of tumors to fasting or reduced food intake, and whether under these circumstances the rate of DNA renewal is still a reliable index of the rate of cell renewal.

In agreement with the first experiment the rate of renewal of liver DNA was found to be most sensitive to fasting (30% of controls). It should be noted that the DNA specific activity and mitotic index of livers are much higher in tumor-bearing mice than in normal mice (c.f. Kelly et al., Cancer Research 11,694, 1951). At the present time the data are not adequate to determine whether the percentage reduction produced by fasting is greater in the livers of tumor-bearing mice than of normals.

Since the reduction in liver DNA specific activity obtained by fasting was similar to the depression found after irradiation (Kelly et al., Medical and Health Physics Quarterly, University of California Radiation Laboratory Report No. UCRL-2661, July 1954), it was considered possible that the irradiation effect was at least partly due to a lowered food intake. Therefore an experiment was carried out on the combined effect of irradiation and fasting. The 2-hour incorporation of P^{32} into DNA of various tissues was determined in 3 groups of mice: normal fed, 24-hour fasted, and 800r irradiated at the beginning of a 24-hour fast. Liver inorganic phosphate specific activities were also measured in these mice. The results are presented in Table IV. A comparison of liver specific activities of the fasted control group vs fasted irradiated group indicates that radiation depresses the incorporation of P^{32} to approximately 40%. This suggests that in earlier experiments in which nonfasted irradiated mice showed a specific activity of only 15% of nonfasted controls, a portion of the effect was due to lower food intake.

The DNA specific activities in the intestines of fasted irradiated mice

were surprisingly low. In all previous experiments it had been found that within 24 hours after 800r the rate of incorporation was back to normal.

These results indicate that changes in food intake must be taken into consideration, particularly where the influence of experimental procedures on livers is to be evaluated.

Table III

DNA Specific activities* of A-strain mice

	Liver	Small Intestine	Spleen	Carcass	Mammary Carcinoma
Fed Normals	2.71 ± 0.66	30.0 ± 2.2	217	29.7 ± 1.7	
Fasted Normals	0.823 ± 0.21	22.2 ± 1.6	121 ± 6.2	21.0 ± 1.4	
Mammary carcinoma (fed)	14.8 ± 0.82	27.2 ± 1.0	218 ± 9.2	25.2 ± 1.0	43.0 ± 2.8
Mammary carcinoma (fasted)	3.60 ± 0.34	18.8 ± 0.68	170 ± 12.9	21.2 ± 1.1	41.0 ± 0.98

* Specific activities are expressed as counts per minute per mgm phosphorus divided by the counts injected per gm mouse. All values were multiplied by 10^3.

Table IV

Specific Activities of B Albino C-Strain Mice

	Liver inorganic phosphate	Liver DNA	Small intestine DNA	Spleen DNA	Carcass DNA
Fed normals	2550 ± 100	1.12 ± 0.16	49.5 ± 2.0	98.2	34.5 ± 1.4
Fasted normals	2650 ± 72	0.510 ± 0.043	45.0 ± 4.5	82.2 ± 9.2	23.8 ± 0.90
Fasted irradiated	2580 ± 160	0.209 ± 0.016	18.1 ± 1.2	1.63	1.14 ± 0.21

HEALTH CHEMISTRY

Nelson B. Garden

CHEMISTRY BUILDING 70

The move to the newly completed Chemistry Bldg. 70 is now essentially completed. Minor adjustments, improvements and additions have received attention in fields such as ventilation, utility extensions, emergency power considerations, protective coatings for work surfaces, etc. Facilities for liquid hydrogen work have been created; refinements have been made in a personnel decontamination station, in areas for the storage of radiochemicals, and in the isotope receival room, where a suitable gloved box, with auxiliary lead shielding, has been installed for use in opening shipments of radioactive materials for detecting leaks and breakage. A training area, containing a manipulator box with two inches of lead shielding, has been set up for new graduate students and others who need to acquire skill in working with the controlling and confining equipment used at Berkeley. A depot for collection of radioactively contaminated platinum, which will provide a closer check on issuances and crediting of platinum and make the accumulation of this material a more efficient operation, has been set up, with Health Chemistry Decontamination Group and the UCRL Stores Department working cooperatively.

EQUIPMENT DEVELOPMENT GROUP

1. A lead-shielded cart was designed, built, and used for housing the channel probe (a probe for use on the internal beam inside the channel of the 60-inch cyclotron), together with its vacuum and water-coolant lines. This set-up provides for cooling additionally through use of compressed helium. Improvements have been made in various existing 60-inch-and 184-inch-cyclotron target holders, and the service dollies for use with the target gear have been modified to afford further protection to personnel, prevention of contamination and faster chemistry on the yield material. A series of bombardments was run on the 60-inch cyclotron, using the internal part of a heavy-ion beam, wherein the chemistry processing boxes were set up inside the cyclotron's shield. This placement of the boxes cut down the processing time--necessary because of the minute-or-less half lives of the yield materials.

2. An enclosure for use in milling large quantities of radioactive metals was completed.

3. New dies were designed for use in equipment for prepressing aluminum slugs containing transuranic materials for irradiation in the Materials Testing Reactor.

4. The radiofrequency welder for use in creating plastic seams has been converted for wide general use.

5. Equipment for use in a nitrogen-atmosphere, negative-pressure box, housing yeast undergoing irradiation from a 3-mc polonium source, has been designed and fabricated. (The yeast is truly resting under

these conditions and is not undergoing aerobic metabolism.)

6. A high-vacuum-line box has been designed, fabricated, and used for transuranic metal production from bombarded thorium; this setup adapts features used in the milling enclosure mentioned in Item 2 above--that is, both this box and the milling enclosure incorporate a moving lucite front which provides access through minimal opening, thus reducing the flow of air. No gloves are used.

7. All basic units for the boxes, dollies, waste system, and process equipment for the Chemistry Bldg. 70 6-inch caves have been drawn and sent to the shops for fabrication.

8. Heating units for adaption of cold-bath heat exchangers have been designed and built; this addition permits use of heat exchangers with heated or cooled columns with simple changeover.

9. A loop adapter for tongs was designed and is being built; this unit was designed as a simple addition to regular tongs for handling ice cream cartons within manipulator boxes.

AIRBORNE ACTIVITY CONTROL GROUP

This group has engaged in the following operations and consultations:

1. Detected, analyzed, and reported to proper authorities outdoor airborne contamination for beta-gamma in the Berkeley area following a Nevada Test Site device experiment.

2. Detected and reported on alpha activity airborne in connection with decontamination of a room in Old Chemistry Building which had been used in Manhattan Project days for processing radium daughters; specified certain personal protection and decontamination techniques; installed and serviced a large exhauster-filter unit for 700-cfm air cleaning and for establishment of a ventilation gradient.

3. Participated in the design, installation, and checkout of inert atmospheric enclosures for transuranic metal production.

4. Critically reviewed blueprints, specifications, and actuality of Donner Laboratory Addition.

5. Continued uranium machine-tool exhaust and air cleaning experiments and design.

6. Continued review of a toxicological program at the Nevada Test Site.

7. Redesigned and tested certain elements of equipment for use in Bldg. 70 caves, including specification of a buffered scrubber liquor to suppress smoke during multicurie chemistry runs.

8. Devised and tested a relatively inexpensive built-in rotameter for continuous air sampler calibration.

Garden

GENERAL

Three members of Health Chemistry participated in a Navy-directed test involving underwater detonation of an atomic device.

Assistance was given in the design, packaging, and shipping of a display of milligram amounts of transuranic isotopes for the Geneva Conference in August.

An order for eleven lead glass windows for use in lead-shielded caves at both Livermore and Berkeley was placed with Penberthy Instrument Company during this quarter. The placement of this combined order resulted in an advantageous bid from Penberthy.

Garden

HEALTH PHYSICS

Burton J. Moyer

STATISTICAL SUMMARY OF MONITORING PROGRAM

Survey Instruments Maintained

β-Ionization Chamber	105
I. D. L. Portable Survey Instruments	24
Cutie Pies	3
Recording Intensity Meters	33
Victoreen Proteximeters	3
Fast-Neutron Proportional Counters	8
Slow-Neutron Proportional Counters	15
Fast-Neutron Proportional Counters (Portable)	21
Slow-Neutron Portable Units	16
Balanced Chambers--Fast Neutron--Portable	3
Special Tissue Wall Survey Instrument	1

Personnel Meters in Use

Total Personnel Covered with Film Badges	3360
Total Man-Days Coverage with Pocket Chambers	8352
Total Man-Days Coverage with Pocket Dosimeters.	8352
Total Man-Days Coverage with Pocket Chambers (S. N.)	8251

Cases of Weekly Exposure Above 0.3r

Weekly Film Expos. above	184" Area	60" Area	Lin. Acc.	Chem.	Other	Total
0.3	0	8	3	14	0	25
0.5	0	3	1	3	0	7
1.0	0	0	0	0	0	0
1.5	0	0	0	0	0	0
2.0	0	0	0	0	0	0
2.5	0	0	0	0	0	0
3.0	0	0	0	0	0	0

Information Division
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