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CALIFORNIA

*Radiation
Laboratory*

MEDICAL AND HEALTH PHYSICS

QUARTERLY REPORT

July, August, September 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

Crocker Laboratory
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Berkeley, California

ASTATINE STUDIES AND RELATED WORK

Patricia W. Durbin, C. Willet Asling, Muriel E. Johnston, Nylan Jeung,
Marilyn H. Williams, Marshall W. Parrott, George Barr,
and Ann Henderson

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

In a previous report,¹ an outline of a series of experiments was set forth that would enable us to determine the effect on reproduction of (a) the surgical removal of the thyroid and parathyroid glands, (b) the radioactive destruction of both these glands with I^{131} , and (c) the destruction of the thyroid only with At^{211} . Supplemental thyroid hormone (TH) was administered intragastrically three times per week to half the animals of the three groups. Basal metabolic rates were obtained for each group and a control group (Table I) to determine the efficiency of thyroidectomy and the effect of thyroid hormone replacement therapy thereon.

Investigation of individual readings showed no correlation between pregnancy or litter size and basal metabolic rates of the controls and those having surgical thyroidectomy + TH.

The surgically thyroidectomized animals receiving the thyroid hormone supplement showed BMR's slightly lower than, but probably not different from, those of the control group. This group also produced more nearly normal litters than any of the other three treated groups.

The surgically thyroidectomized group had a mean BMR that is probably different from that of the control animals. The quality and size of litter resembled those of the At^{211} and I^{131} groups, but are distinctly different from those for the control animals.

¹ Medical and Health Physics Quarterly Report, UCRL-3386, April 1956, p. 5.

Table I

Effects of thyroidectomy by various means on litter quality and basic metabolic rate in female Sprague-Dawley rats

Group	Litter Quality				Mean BMR
	Non-pregnant	Very abnormal	Abnormal	Normal	
Control	3	0	1	6	53.1
Surgical thyroidectomy + TH	2	5	2	3	48.8
Surgical thyroidectomy	6	5	1	1	45.7
Radiothyroidectomy by I^{131}	9	0	2	1	37.1
Radiothyroidectomy by At^{211}	7	0	0	0	34.3

Segregation as to litter quality is as follows: nonpregnant; very abnormal (all offspring born dead); abnormal (1 to 2 survivors, remainder of offspring dead); normal, (majority born alive and raised to weaning age).

The At^{211} and I^{131} animals were found to be very much more affected than the control and surgically thyroidectomized + TH groups with respect to BMR and to litter production, both in quality and number of litters.

A 25% increase in thyroid hormone would probably raise the BMR of the surgically thyroidectomized + TH group to the control level.

The data indicate that it might be advisable to repeat the experiments with the surgically thyroidectomized + TH group in an effort to raise the BMR to that of the corresponding untreated group.

The At^{211} radiothyroidectomy + TH and I^{131} radiothyroidectomy + TH groups are currently being bred, and the results should be available by the end of the present quarter.

STRONTIUM-90 IN THE RHESUS MONKEY

The six rhesus monkeys that have been receiving 0.007 μC of an equilibrium mixture of $\text{Y}^{90}:\text{Sr}^{90}$ orally five days a week since June 25, 1956, do not seem to be assimilating the radioactive elements. Excretion assays have been run on urine and feces, each pooled weekly. Recoveries have ranged, on the average, from 100.1% to 115.7%. (See Table II.)

The assays will be checked by plating smaller aliquots onto gold and counting with better geometry. A chemical analysis involving calcium-strontium oxalate precipitation will also be tried. This method should carry down the Sr^{90} and eliminate some of the interfering salts.

In order to increase Sr^{90} uptake, three of the six monkeys have been placed on a milk substitute (casein, butter, and sugar) to reduce calcium content of the diet. MacDonald et al. report that a decrease in calcium intake increases Sr^{90} assimilation in rats, but they cite a milk-powder diet as an exception.² Our results indicate that milk powder supplies more than enough calcium to keep Sr^{90} from being assimilated by adolescent or young adult monkeys. The monkeys in this colony receive much more calcium in their diet than they would in their natural environment.

X-rays of the skeletons of these animals have been transmitted to Dr. G. Van Wagenen of Yale University for age estimation.

Table II

Excretion of Sr^{90} , Y^{90} by rhesus monkeys receiving equilibrium mixture			
Weeks	Average for six monkeys (percent)		
	Feces	Urine	Total
1	102.6	11.9	114.5
2	99.2	16.5	115.7
3	94.2	18.9	113.1
4	90.7	9.44	100.1
5	86.5	20.0	106.5
6	84.7	14.2	101.6
7	96.5	11.9	108.4
8	97.6	11.4	109.0

² N. S. MacDonald, P. C. Spain, F. Ezmirlan, and D. E. Rounds, Effects of Calcium and Phosphate in Foods on Radiostrontium Accumulation, UCLA-317, Dec. 1954.

Bone biopsy samples have been obtained from the monkeys in the "Strontium Family," one strontium-injected adult female, and one control monkey. Strontium-90 content was measured by Nuclear Science and Engineering Corporation. Calcium analyses were performed in duplicate by an oxalate precipitation followed by titration with permanganate. The results of these measurements are given in Table III.

Table III

Radiostrontium and calcium content of tail bone samples
from monkeys injected with or born with Sr⁹⁰

	Sr ⁹⁰ content of tail bone (dps/mg ash)	% calcium
Stupe - adult male (22 mo. P.I.)	595	35.0
Rosy - adult female (23 mo. P.I.)	295	35.7
Willie - first offspring of Stupe and Rosy (age 20 mo.) ^a	0.5	35.8
Betty - second offspring of Stupe and Rosy (age 10 mo.) ^a	0.83	33.4
Pat - Sr ⁹⁰ - treated young adult female (3 mo. P.I.)	1530	36.3
Alice - control adult female (no Sr ⁹⁰)	0.02	35.7

^a Age when bone biopsy performed.

The calcium content of tail vertebrae given by duplicate calcium determination on the four adult monkeys was $35.68 \pm .33\%$ of ash.

Calcium analyses are currently being run on the daily monkey ration so that Sr⁹⁰ assimilation can be correlated with daily calcium intake.

STRONTIUM-90 UPTAKE IN INFANT MONKEY "HENRY"

Since June 25, 1956, "Henry" has been receiving 320 disint. per sec of the equilibrium mixture of Y^{90} : Sr^{90} five days a week. Pooled daily excretions are being assayed. Thus far, it is still not feasible to collect urine and feces separately, so that exogenous and endogenous Sr^{90} excretion cannot be differentiated. To date he has retained, on the average, 20% of the weekly strontium dose. "Henry" was measured for Sr^{90} content on May 28, 1956, six days after birth, by use of the *in vivo* counting method employed for the assay of the other two infant monkeys described previously.³ No Sr^{90} was detectable at that time. He was counted again on September 13, 1956, approximately three months after the initiation of the Sr^{90} supplement, and at this time he contained detectable radioactivity. The *in vivo* measurement of Sr^{90} is not quantitative, but can be taken as a good indication of the accuracy of the excretion measurements. So far, no gross changes in appearance or growth rate have been observed that might be attributed to his body burden of Sr^{90} .

ELIMINATION OF LETHAL DOSES OF IODINE-131

Two G-M tube counters have been assembled for *in vivo* determination of whole-body retention in rats of strong gamma emitters.

Tubes with 2.5-in. diameter thin mica windows were used. The tubes were covered by 0.25-in. thick lead cylinders that extended 1 in. beyond the tube faces. Each G-M tube and shield assembly was mounted on a movable holder on either side of, and directed toward, a plastic rat holder. The counting rate for any animal was adjusted to a maximum for the G-M tube without introducing a coincidence correction by varying the tube-animal distance and by the use of aluminum and lead filters.

Groups of rats were given high-level doses of I^{131} . As a check on counting by the above method, some of the animals were sacrificed, and I^{131} retention was determined by scintillation counting of the tissues. Preliminary results showed a difference of about 5% between the two counting methods.

Several large groups of rats have been given I^{131} at dose levels of 90, 50, 10, and 1 $\mu\text{C/g}$ (tracer). The animals were counted by the above *in vivo* method daily for 9 days, then at intervals of 3 days up to 21 days. Background counting rates varied from 100 to 500 cpm, making it necessary to count for relatively long periods. Four thousand counts were collected for each animal, limiting the statistical error to about 2% at a counting rate of only twice background. Preliminary results showed a retention at 1 day of about 20% in the tracer animals, and about 50% in the high-level animals, with no statistical differences among the high-level groups. During the first few days after injection retention was consistently higher in the high-level rats--an important factor in assessing radiation damage.

³ Medical and Health Physics Quarterly Progress Report, UCRL-2823, Jan. 1955.

EFFECT OF THYROID-HORMONE THERAPY IN THE RAT AFTER LARGE DOSES OF IODINE-131

A study of the effect of replacement thyroid-hormone (TH) therapy on health and longevity of rats receiving high levels of I^{131} is in progress. Female Sprague-Dawley rats, 56 to 60 days old and weighing on the average 175 g, were given I^{131} intravenously at dose levels of 10, 50, and 90 $\mu\text{C/g}$ of body weight. Animals were injected at each dosage level on four different dates over a 3-month period in order to minimize the radiation hazards to personnel.

Measurements of body weight, red blood cell count, white blood cell count, hemoglobin, and microhematocrit are being made periodically. Data are complete to 35 days for all the groups, totaling 98 rats. The greatest depression in white blood cell counts was at 7 days postinjection, when the decrease was roughly proportional to the amount of I^{131} administered. The mean white blood cell counts of 25 to 35 rats per group at 7 days post-injection were 11.75 ± 1.57 , 5.95 ± 0.58 , and 3.68 ± 0.37 thousands per mm^3 for the 10-, 50-, and 90- $\mu\text{C/g}$ groups respectively. A definite lymphopenia was observed at the 7-day postinjection period at the highest dose level.

Thyroid hormone replacement therapy was begun 19 days post-injection. One-half the animals at each dose level are receiving 6 mg desiccated thyroid substance, suspended in water, by stomach tube three times weekly.

After 2 weeks of therapy (35 days postinjection), the treated rats at each I^{131} dose level weigh 20 g more on the average than the untreated rats. This difference is statistically significant.

Basal metabolic rates are in progress to determine the efficiency of the thyroid-hormone therapy.

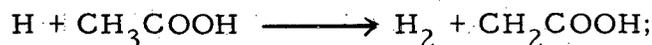
RADIATION CHEMISTRY

Warren M. Garrison in charge

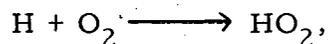
Boyd Weeks, Michael Jayko, Winifred Bennett,
Joseph Ward, and Sibyl Cole

RADIATION-INDUCED OXIDATION
OF ACETIC ACID-OXYGEN SOLUTIONS

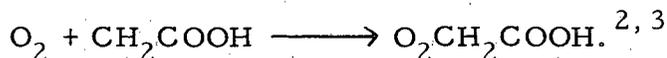
In the radiolysis of oxygen-free acetic acid solutions, the primary radicals H and OH are removed via



Subsequent combination of CH_2COOH gives succinic acid as the principal product.¹ However, if oxygen is present, H is removed by

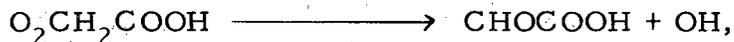
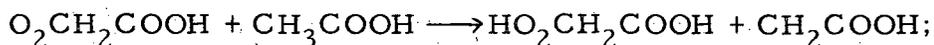


while CH_2COOH combination is blocked by



This suppression of succinic acid production by oxygen is accompanied by formation of glycolic acid, glyoxylic acid, oxalic acid, formaldehyde, and carbon dioxide.

It has been shown that initial G values for glycolic, glyoxylic, and oxalic acids are essentially independent of dose.⁴ These results indicate that the acids are not formed through consecutive oxidation steps as the concentration of products increases during irradiation. Oxidation apparently occurs through parallel reactions initiated by the formation of the common precursor, $\text{O}_2\text{CH}_2\text{COOH}$. It is unlikely that reactions that lead to chains, e. g.,



contribute appreciably to the yield of observed products, since there is no

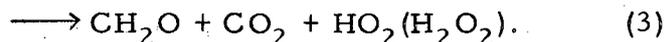
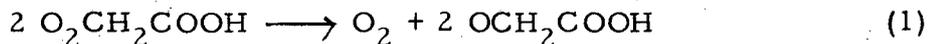
¹ Garrison, Bennett, Cole, Haymond, and Weeks, J. Am. Chem. Soc. 77, 2750 (1955).

² Garrison, Haymond, and Weeks, Radiation Res. 1, 97 (1954).

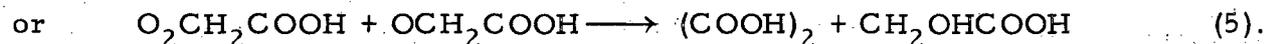
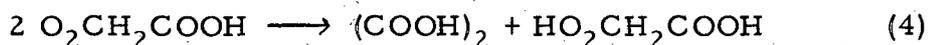
³ H. R. Haymond, Some Effects of Dissolved Oxygen on the Heavy-Particle Irradiation of Aqueous Acetic Acid (Thesis), UCRL-2697, Sept. 1954.

⁴ Medical and Health Physics Quarterly Report, UCRL-3479, July 1956, p. 11.

evidence that more than one acetic acid molecule is removed per OH radical initially formed. It is proposed that the sequence of Eqs. (1), (2), (3) represents the simplest mechanism for the formation of glyoxylic acid and formaldehyde⁵ under the irradiation conditions of this study:^{6,7}



The formation of oxalic acid can be interpreted on the assumption that some of the $\text{O}_2\text{CH}_2\text{COOH}$ radicals are oxidized to give the intermediate O_2CHCOOH . Radicals of the latter type are reported⁸ to undergo isomerization via $\text{RCHO}_2 \longrightarrow \text{RCOOH}$. The fact that oxalic and glycolic acids are observed in approximately equal molar amounts at the lower dose values suggests that their formation may be represented by



Glycolic acid would be obtained from Reaction (4) through hydrolysis of $\text{HO}_2\text{CH}_2\text{COOH}$.

Studies now in progress will provide information on the effects of beam intensity and linear energy transfer on the absolute and relative yields of oxidation products.

⁵ Formaldehyde is also formed as an initial product in low yield (Reference 3).

⁶ Reactions of the type of Eq. (1) have been proposed as a principal process in the oxidation of free methyl radical. (Raley, Porter, Rust, and Vaughan, J. Amer. Chem. Soc. 73, 15 (1951)).

⁷ Although glyoxylic acid is the principal acid product under the conditions of high radical concentration obtained in cyclotron irradiations (see Reference 1), it must be assumed that the relative yields of acid products may be different at lower radical concentrations, e. g., in x-ray radiolysis. In the latter case, for example, reaction of the type $\text{RO}_2 + \text{H}_2\text{O} \longrightarrow \text{ROH} + \text{HO}_2$ may compete with reaction 1 above to give glycolic acid as the principal product acid. (T. J. Sworski, Radiation Res. 1, 231 (1954)).

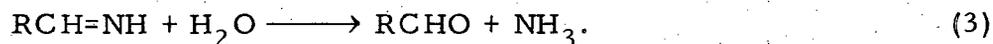
⁸ A. Rieche and R. Meister, Ber. deut. chem. Ges. 64B, 2335 (1931). These authors show also that hydrolysis of RCHO_2 to the corresponding aldehyde may occur. In the case of O_2CHCOOH , this reaction would yield $\text{CHOCOOH} + \text{H}_2\text{O}_2$.

RADIATION-INDUCED REDUCTION OF FORMIC ACID
IN OXYGEN-FREE SOLUTION

Studies of reduction processes in the radiolysis of aqueous formic acid are continuing. The formation of glyoxylic, glycolic, oxalic, tartronic, mesoxalic, and tartaric acids in irradiated formic solutions⁹ is being studied as a function of beam intensity and linear energy transfer. These processes of radiation synthesis will be considered in a future Quarterly Report.

INDIRECT ACTION OF RADIATION ON THE -NH-CH₂-LINKAGE
IN DIETHYLAMINE (A MECHANISM FOR
RADIATION-INDUCED DECOMPOSITION OF THE PEPTIDE CHAIN)

Recent considerations^{10, 11} of the indirect action of radiation on aqueous glycine indicate that decomposition of glycine at the locus of the N-C bond to give ammonia and glyoxylic acid occurs through intermediate formation of imino acetic acid. This formation of ammonia and aldehyde through oxidation of primary amine to imine by indirect action in oxygen-saturated solution has been represented by^{10, 12}



It has been found in studies at this laboratory that secondary amines undergo a similar reaction to give primary amine and aldehyde, presumably through the intermediate formation and subsequent hydrolysis of the N-alkylimine or Schiff base, RCH=NR.

The 60-inch cyclotron at the Crocker Laboratory was used as a radiation source. Irradiations were made with 12-Mev protons at a beam current of 0.01 microampere. The target cells, irradiation techniques, and procedures were those which have been previously described.¹³ Oxygen aeration was maintained during irradiation. The diethylamine solutions (0.1 M) were adjusted to pH3 with sulfuric acid to prevent escape of volatile

⁹ Garrison, Bennett, and Jayko, J. Chem. Phys. 24, 631 (1956).

¹⁰ W. M. Garrison and B. M. Weeks, J. Chem. Phys. 24, 616 (1956).

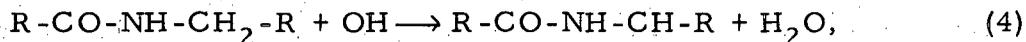
¹¹ W. M. Garrison and B. M. Weeks, J. Chem. Phys. 25, (in press).

¹² See Barron, Ambrose, and Pearson, Radiation Research 2, 431 (1955).

¹³ Garrison, Raymond, and Weeks, Radiation Research 1, 97 (1954).

base. Carbonyl product was precipitated as the 2, 4-dinitrophenylhydrazone. This fraction was chromatographed by the method of Meigh¹⁴ and was found to contain only the acetaldehyde derivative. The yield of the isolated 2, 4-dinitrophenylhydrazone was determined by the method of Lappin and Clark.¹⁵ Ethylamine and diethylamine were selectively eluted from Dowex-50 with hydrochloric acid which was gradually increased in concentration from 2 N to 4 N to effect a maximum separation; this method is described elsewhere. The yield of separated primary amine was determined by the method of Ormsby and Johnson.¹⁶ Initial G values (molecules of product per 100 ev absorbed energy) for ethylamine and acetaldehyde¹⁷ were found to be ~0.8 and ~0.5 respectively for protons of 12 Mev.¹⁸

These results suggest that reactions of the type



may be involved in the radiation-induced cleavage¹⁹ of the peptide chain. Also of significance in this regard is the fact that the hydrolysis reaction, Eq. (6), provides a specific mechanism for postirradiation effects which have been observed²⁰ in certain protein systems. Experimental work has been initiated to determine if, through indirect action of radiation on the peptide chain, the amide and carbonyl terminal linkages are formed at the locus of cleavage.

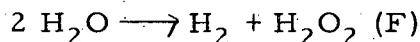
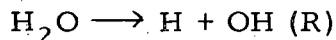
¹⁴ D. F. Meigh, Nature 170, 579 (1952).

¹⁵ G. R. Lappin and L. C. Clark, Anal. Chem. 23, 541 (1951).

¹⁶ A. A. Ormsby and S. Johnson, J. Biol. Chem. 187, 711 (1950).

¹⁷ Jayson, Scholes, and Weiss, report that acetaldehyde and an oxime are formed in the x-ray radiolysis of oxygen-containing diethylamine solutions at pH values above 6, J. Chem. Soc. 2594 (1955).

¹⁸ Radiation yields obtained in this laboratory for water decomposition by 12-Mev protons via the radical and forward reactions



are: $G_R = 2.34$, $G_F = 1.11$

(Medical and Health Physics Quarterly Report UCRL-3479, July 1956, p. 14.)

¹⁹ H. A. Scheraga and L. F. Nims, Arch. Biochem. and Biophys. 36, 336 (1952).

²⁰ R. S. Anderson, Brit. J. Radiol. 27, 56 (1954).

Preliminary results indicate that the carbonyl linkage is formed in the irradiation of oxygen-saturated pepsin solution (0.8%) and that the chemical change occurs in the high-molecular-weight material. The analytical procedures employed for the carbonyl determination preclude the possibility that reaction can be attributed to a radiation-induced oxidation of amino acids, which may be formed by hydrolysis during irradiation. The following technique is being used in investigating the formation of carbonyl derivatives: Immediately after irradiation (carried out in sealed oxygen-saturated glass cells) the solutions are treated with platinum black to remove hydrogen peroxide. Hydrazone derivatives of the carbonyl groups are formed on the addition of 2,4-dinitrophenylhydrazine-hydrochloric acid solution. The entire target solution is then dialyzed to remove excess reagent and protein fragments, which may be formed during irradiation. Hydrolysis of the high-molecular-weight fraction yields hydrazone derivatives which are as yet unidentified. Preliminary tests indicate that a major part of the hydrazone fraction is composed of di-keto derivatives. This would appear to indicate that OH attack occurs preferentially at serine and (or) threonine positions of the peptide chain.

REPORT ISSUED

A detailed study of mechanism in the radiolysis of aqueous glycine is summarized in the report:

Boyd M. Weeks, Indirect and Direct Action of Heavy-Particle Radiation on Glycine in Aqueous Solution (Thesis), UCRL-3071, July 1955.

BIOLOGICAL STUDIES OF RADIATION EFFECTS

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ULTRAVIOLET-INDUCED AUXOTROPHS OF YEAST

Robert K. Mortimer and Ruth S. Lerner

A nonclumpy haploid strain of Saccharomyces cerevisiae with no nutritional requirements, but carrying two genetic fermentation markers, was exposed to various doses of ultraviolet radiation. Surviving colonies were selected at random and streaked on synthetic incomplete and synthetic complete medium. The complete medium contained 19 amino acids and 5 purines and pyrimidines absent in the incomplete medium. In a few cases also, a number of vitamins were left out of the incomplete medium.

The cells before irradiation were capable of growing on the incomplete medium. After irradiation, from 1% to 5% of the surviving colonies (depending on the dose) failed to grow on the incomplete medium but grew on the complete medium. A few failed to grow on either. The former were isolated and their nutritional requirements characterized by auxanographic procedures. A number of pink colonies were isolated directly from the survivors and these all showed adenine dependence as reported previously for this organism.

A total of 41 amino acid mutants, 3 adenine (pink and white), 4 uracil mutants, and 4 vitamin mutants were identified. Also, 11 mutants with multiple requirements (2 to 4) were characterized. The ones so far tested for segregation appear to possess a single genetic block causing the multiple requirements. Allelism tests are being carried out, both against markers already available in yeast and within groups of the above mutants showing the same phenotypic requirements.

A number of the mutants have been tested for segregation, and their markers are being incorporated into stocks containing markers already mapped.

The general plan is to obtain strains with some well-marked linkage groups which can then be used in a more detailed study of the genetic effects of radiation in this microorganism.

HEAT INACTIVATION OF YEAST

Freddie Sherman

The heat inactivation of several strains of Saccharomyces cerevisiae has been studied under various conditions. Survival curves have been obtained by suspending the yeast cells in distilled water of the desired temperature and withdrawing aliquots as a function of time. The yeast suspensions were then plated on yeast extract dextrose agar and incubated for several weeks, and then counted.

It was found that the age of the culture used in the experiment has a great effect on the survival curve; a 1-day culture has a simple exponential survival curve, while older cultures show mixed sigmoid curves and greater resistance.

It was also found that a "petite" strain (lacking cytochrome a and b) shows a greater sensitivity to heat than the wild type.

The haploid and diploid strains show no significant difference in heat sensitivity, but higher ploidies are more sensitive.

It was found that a large number of the surviving colonies of the heat-inactivated wild type mutate to the "petite" type; the fraction increases with increasing time inactivated.

CONTINUOUS PROPAGATION OF SACCHAROMYCES CEREVISIAE

Graeme Welch

The apparatus for culturing yeast cells continuously in liquid medium under controlled conditions is now equipped to record continuously the population density and pH of the culture. Population-density-damped oscillations of period long compared with the generation time have been observed and correlated with similar oscillations in pH. The pH oscillations lag the population-density oscillations by approximately one-third of a cycle. Measurements and data analysis are continuing.

DNA SYNTHESIS AND INCORPORATION OF PHOSPHORUS-32 IN IRRADIATED EHRlich ASCITES CELLS

Lola S. Kelly, J. Dorothy Hirsch, and Genevieve Beach

This material has been presented for publication in the Proceedings of the Society for Experimental Biology and Medicine. In this work experiments were carried out 4 to 6 days after the inoculation of approximately 2×10^7 Ehrlich ascites tumor cells in mice. When the 2-hour incorporation of P^{32} into DNA was measured at various times after irradiation (800 r total-body x-irradiation), no significant depression in DNA specific activity was observed until 1 day. Measurements of mean cell volume, mean DNA content per cell, and mean total nucleic acid content per cell at 13 and 20 hours revealed that all three quantities increased at approximately the

same rate, closely matching the growth rate of the unirradiated tumor and the rate of DNA formation estimated from the incorporation data. The increased DNA content per nucleus after radiation was confirmed by Feulgen microspectrophotometry. At 48 hours after irradiation, cell volume and total nucleic acid per cell had risen even higher, while DNA per cell showed little further increase. The data suggest that the irradiated cells continue to synthesize DNA until they reach the premitotic DNA content (octoploid in the Ehrlich cells) and are arrested there because they are unable to go through mitosis.

MISCELLANEOUS STUDIES OF METABOLISM AND BLOOD CELL HISTORY

Myron Pollycove

Iron kinetics was determined in 22 patients with anemia, polycythemia, and leukemia. These studies demonstrated various combinations of increased and decreased red cell formations together with normal or increased red cell destruction.

Hemoglobin formation rates were determined in 11 patients.

Erythrocytes longevity was studied in 14 patients by use of Fe⁵⁹, Cr⁵¹, and C¹⁴ glycine.

Cobalt-60-vitamin B-12 was employed to determine vitamin B-12 absorption in metabolism in five patients.

Metabolism of a therapeutic iron dextrin compound was studied by means of labeling with Fe⁵⁹. This study was performed in three patients.

Uric acid metabolism (with C¹⁴-labeled uric acid) was studied in one patient with polycythemia and gout. In this study it was found that approximately 25% of the extracellular fluid uric acid was metabolized to CO₂ within 1 week.

REPORT ISSUED

A paper on "The Effect of Diagnostic Dental Radiography on the Lymphocyte Count and on the Diurnal Tide of Human Leukocytes," by R. Lowry Dobson and Mary M. Chupp, has been issued as UCRL-3574, Oct. 26, 1956.

HEALTH CHEMISTRY

Nelson B. Garden

OPERATIONS DIVISION

In order to reduce the accumulated backlog of liquid waste, the cement-vermiculite mixture has been used as a gelling agent to solidify approximately 360 gallons of the 1330 gallons of waste on hand. After reduction of the backlog, investigations will be resumed to determine the equipment, procedures, and gelling agent that will provide the safest and most economical operation.

The optimum design for a target-handling cart for use with the 60-in. cyclotron targets is still being sought, and bugs are being worked out of a new model put into use during this quarter. Cross contamination; decontamination; shielding for personnel; foolproof vacuum, air and water lines; and speed of manipulation are some of the many aspects to be considered. Extensive radiochemical studies are being made of the cooling water, after each use, in order to get clues as to the source of malfunction.

The best means of storing emanation-emitting samples, when not in immediate use by the researchers, is being sought. Sealed samples, not evaporated to dryness before sealing, present an explosion hazard, whereas vented liquid samples are unwieldy. The holders of these items are being consulted as to their opinions on the various conditions of the emitters, ease of converting them to a desirable storage form, etc.

Pending the installation of a covered area for concreted waste drum storage, means have been provided to stack the barrels in a tilted position, preventing rainwater accumulation in these drums. It is hoped thus to eliminate the extensive checking and reassurances previously required when such rainwater was spilled in the later handling of these drums.

Donner Laboratory's animal experiments involving radioactivity have been extended to their facilities in the Cancer Research Area in Strawberry Canyon, where the Health Chemistry monitoring services are now being provided.

A special shelter for certain radioactive waste, consisting of Donner Laboratory's sacrificed animals, awaiting pickup outside the laboratory on Gayley Road, has been designed and put into use. In spite of frequent pickups this became necessary in order to provide outside receptacles for such odorous items, yet it had to be made foolproof with respect to passing children and dogs.

EQUIPMENT DEVELOPMENT AND TECHNICAL SERVICES

The lead housing for the 2500-curie Co^{60} source, created in the MTR and received during the last quarter, is nearing completion. Certain sections were radiographed, and one piece revealed a cavity about 3 in. in diameter by $3/4$ in. in height; the part was recast. The source will be loaded into the housing in the near future; the 6-in. cave in Bldg. 5, modified slightly for this operation, will receive the shipping cask with the 2500 curies, and the pellets will be removed, cleaned, and inserted in their proper permanent holders, which will then be positioned in the lead housing.

A 120-curie Co^{60} source, used in radiographing this lead housing, was found to be in need of slight repair; this was done in the Bldg. 5 6-in. cave also.

Standard equipment for personnel protection and contamination control continues to be supplied to the researchers on request. Special features--large and small--for particular problems have also been provided; these problems arose in such experiments as the following:

1. Dr. Nierenberg's molecular beam apparatus; the vaporization setup has worked satisfactorily; decontamination of the equipment presents a fairly lengthy task.
2. Dr. Wallmann's transuranic crystal-growing equipment.
3. Dr. Jeffrie's microwave spectroscopy work in Le Conte Hall.
4. Creation and refinement of thallium bombardments for use in the molecular beam apparatus.
5. Preparation of Glo-balls for use in studying the field in the tank of the new Heavy Ion Linear Accelerator; americium and curium have been used to date.
6. Mass spectroscopy work.
7. Bombardments in 60-in. cyclotron of heavy elements in milligram amounts.
8. Use of Ca^{45} in micro-muffle furnace in Donner Laboratory.

Another set of napkin rings (MTR-irradiated plutonium in 13 rings), consisting of some 4 g of plutonium as parent material, irradiated for more than three years, was received and processed in the standard 6-in. cave assembly in Bldg. 70, an experiment similar to that done in the October-December 1955 quarter. In addition, two re-irradiated samples from this previous run, consisting of americium and curium as parent material, were processed and prepared for subsequent 60-in. cyclotron bombardments. Fractions from the current napkin rings are being prepared for

re-irradiation in the MTR, as before. Jordan meters with 15-ft cables were used, permitting the probes to be located in the collimators behind the cave for spot-checking samples through any one of the three cave boxes.

INSTRUMENTATION

Work has been done in adapting a gamma pulse-height analyzer for use in studying the I^{131} absorption in charcoal drums.

A circuit has been worked out and a unit converted for checking a high-range Juno instrument; the extension is from the present 5 r/hr to 50 r/hr full scale. A 120-curie Co^{60} source was used in the study of the instrument.

Designs have been worked out to install improved meter movements in the Jordan meters; an enlarged case is required in the new designs.

AIRBORNE ACTIVITY CONTROL

The group completed participation in the nationwide fallout studies in connection with the Spring Pacific tests.

The setup of refurbished air-cleaning equipment for the napkin ring processing, mentioned above, was completed at a total air discharge of 0.02 cfm, with 20 cfm recycling through boxes constituting work areas.

Charcoal and caustic samplers and pilot plant decontamination trains for decontaminating I^{131} -laden air from animal experiments was installed and operations were initiated. This study will be continued.

The group developed techniques and process equipment parameters for total dissolver off-gas capture of noble gases and associated aerosols in runs of the napkin ring type; this work was submitted to the Equipment Development group of Health Chemistry for application and trial.

The group is studying needed improvements in box-manifold exhaust systems; a Scully-Rowell circuitry is being tried for the advantages of its fail-safe features.

GENERAL

A meeting attended by Health Chemistry members and architects was held to discuss the remodeling of the ventilation system in Donner Laboratory.

HEALTH PHYSICS

Burton J. Moyer

STATISTICAL SUMMARY OF MONITORING PROGRAM

Survey Instruments Maintained

Beta-gamma meters	29
IDL 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 (Berkeley and Livermore)	4434
Total man-days coverage with electroscopes (Berkeley only)	4475
Total man-days coverage with dosimeters (Berkeley only)	2675

Bevatron

Electroscopes -- 1800 man-days -- Approx. 20 used per day for 3 months

Bldgs. 10 and 53

Slow-neutron chambers--1325 man-days--Approx. 15 used per day
for 3 months

Dosimeters 1325 man-days--Approx. 15 used per day
for 3 months

Electroscopes 1325 man-days--Approx. 15 used per day
for 3 months

Crocker

Slow-neutron chambers 900 man-days--Approx. 10 used per day
for 3 months

Dosimeters 900 man-days--Approx. 10 used per day
for 3 months

Electroscopes 900 man-days--Approx. 10 used per day
for 3 months

Bldg. 70

Slow-neutron chambers 450 man-days--Approx. 5 used per day
for 3 months

Dosimeters 450 man-days--Approx. 5 used per day
for 3 months

Electroscopes 450 man-days--Approx. 5 used per day
for 3 months

Cases of Weekly Exposure Above 0.3 r

<u>Weekly film expos. above</u>	<u>184-inch area</u>	<u>60-inch area</u>	<u>Linac</u>	<u>Chem</u>	<u>Other</u>	<u>Total*</u>
0.3	0	15	17	7	3	42
0.5	0	5	1	2	2	10
1.0	0	1	0	0	0	1
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
4.0	0	0	0	0	0	0
6.0	0	0	0	0	0	0
6.5	0	0	0	0	0	0

*excluding Livermore

Moyer

Information Division
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