

UNIVERSITY OF
CALIFORNIA

*Radiation
Laboratory*

TWO-WEEK LOAN COPY

*This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. División, Ext. 5545*

BIOLOGY AND MEDICINE QUARTERLY REPORT
April, May, June 1957

BERKELEY, CALIFORNIA

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

UCRL-3880
Biology and Medicine

UNIVERSITY OF CALIFORNIA

Radiation Laboratory,
Berkeley, California

Contract No. W-7405-eng-48

BIOLOGY AND MEDICINE QUARTERLY REPORT

April, May, June 1957

July 29, 1957

Printed for the U. S. Atomic Energy Commission

BIOLOGY AND MEDICINE QUARTERLY REPORT

April, May, June 1957

Contents

BIOLOGICAL STUDIES OF RADIOACTIVITY AND IRRADIATION

BIOLOGICAL EFFECTS OF INTERNALLY DEPOSITED RADIOISOTOPES

Induction of Mammary Tumors by Astatine-211. II 3

RADIATION CHEMISTRY

Protein 14
Effects of Dose Rate in the Radiolysis of Aquo-Organic Systems . 15
Radiation-Induced Synthesis of Higher-Molecular-
Weight Compounds from Formic Acid in Aqueous Solutions. 16
Radiation-Induced Oxidation of Acetic Acid in
Oxygenated Solution 19

BIOLOGICAL STUDIES OF RADIATION EFFECTS

Radiobiological Studies 21
The Effect of X-Rays on Egg Hatch and Egg Laying in
a Wasp (Mormoniella) 23
Rate of Formation of Lymphocytes 25
Studies on the Embryonic Nucleoprotein Fraction that
Stimulates Growth in Tissue Culture 26
Report Issued 26

RADIATION DETECTION AND PROTECTION

HEALTH CHEMISTRY

Building and Remodeling 27
Apparatus and Equipment 28
Miscellaneous 29

HEALTH PHYSICS

Statistical Summary of Monitoring Program 31
He³ Spectrometer Filling System. 32
Report on Noble Gas Scintillation 33

*Preceding Quarterly Reports: UCRL-3758, UCRL-3653

BIOLOGY AND MEDICINE QUARTERLY REPORT

April, May, June 1957

July 29, 1957

BIOLOGICAL STUDIES OF RADIOACTIVITY AND IRRADIATION

Crocker Laboratory
University of California
Berkeley, California

BIOLOGICAL EFFECTS OF INTERNALLY DEPOSITED RADIOSOTOPES

Patricia W. Durbin and C. Willet Asling in charge

INDUCTION OF MAMMARY TUMORS BY ASTATINE-211. II.

Muriel E. Johnston, Nylan Jeung, Marilyn H. Williams,
Marshall W. Parrott, George Barr, and Ann Henderson

The design of a series of experiments on the induction of mammary tumors in female Sprague-Dawley rats following the administration of At^{211} was presented in the Preceding Quarterly report.¹ Group A animals--treated controls--received 0.5 $\mu C/g$ body weight of At^{211} at 55 days of age; Group B--TH-pretreated--received 8 daily subcutaneous injections of 230 μg of l-thyroxine prior to the administration of At^{211} ; and Group C--TH-therapy--received approximately 1 μg of l-thyroxine per day in the drinking water from the seventh day after the At^{211} injection until death or sacrifice.

The numbers and classifications of mammary tumors observed in the normal controls and in each of the three At^{211} -treated groups are shown in Table I. The rats were classified, according to the method of Davis et al.,² as either tumorous or nontumorous, regardless of the number of individual tumors any one rat possessed. There were four cases in the At^{211} -treated Group (A), three cases in the TH-pretreated Group (B), and one in the TH therapy Group (C) where two or more benign tumors were found in a single rat. These were tabulated as single entries under the classification of the largest of the tumors. Three rats in Group (A), two in Group (B) and one in Group (C) had more than one malignant tumor; these were classed as single entries according to the most malignant of the tumors present. The two cases in Group (B) and the one case in Group (C), in which rats possessed both benign and malignant tumors, were classified only as malignant-tumor-bearing animals.

¹Durbin, Asling, Johnston, Jeung, Williams, Parrott, Barr, and Henderson, in Biology and Medicine Quarterly Report, UCRL-3758, April 1957, p. 20.

²Davis, Stevenson, and Busch, Tumor Incidence in Normal Sprague-Dawley rats, Cancer Research 16, 194-197 (1956).

Table I

Incidence of and classification of tumors induced in femal Sprague-Dawley rats following the administration of $0.5 \mu\text{C/g}$ body weight of At^{211} at age 55 days. The experiment was terminated when all animals were 420 days of age.

	Untreated controls	Group A At^{211} only	Group B At^{211} and thyroxine pretreated	Group C At^{211} and thyroxine therapy
<u>Number of rats autopsied</u>	46	57	36	16
<u>Mammary tumor incidence (%)</u>	8(17.5)	43(75.5)	22(75)	12(75)
<u>Total benign tumors</u>	5(62%) ^a	15(35%)	17(63%)	6(50%)
Adenoma and fibroadenoma	3	9	9	6
Adenofibroma	1	6	8	-
<u>Total malignant tumors</u>	3(38%)	28(65%)	10(37%)	6(50%)
Adenocarcinoma	2	12	6	3
Miscellaneous carcinoma	1	11	2	3
Sarcoma	-	5	2	-
<u>Other neoplasms</u>				
Chromophobe adenoma of the pituitary		10	2	2
Adenoma of the adrenal cortex		10	3	2
Miscellaneous (see text for exact descriptions)		3	2	-

^aIncludes one fibroma

It is apparent from Table I that the administration of At²¹¹ to female rats of this strain and age resulted in a fourfold increase in mammary tumor incidence, regardless of whether they did or did not receive thyroxine before or after the At²¹¹ injection. However, the proportion of malignancies in the animals that were given only the At²¹¹ injection (Group A), was greater than in the normal controls or in the rats that received pretreatment with thyroxine (Group B). The difference between the percentage of malignancies in Groups A and B was significant to the 5% level of confidence, that is, greater than two standard deviations.* Because of the small number of tumor specimens available from the normal control group, the apparent twofold increase in the proportion of malignancies in Group A is valid only to the 30% level (one standard deviation).

Histopathology

Histopathologic examination was made of the major endocrine glands, the lymphatic tissues, the lung, liver, and kidney, and the tumors. All were dehydrated with dioxane, embedded in paraffin, and sectioned at 6 μ (pituitaries at 4 μ), and all were stained with hematoxylin and eosin except the pituitaries, which were stained by the Mallory-Azan procedure.

Treated Controls (Group A)

Thyroid. The thyroid glands of the controls showed substantial damage. Characteristically, they contained very small follicles, whose epithelium was low cuboidal, and whose colloid was dense and sometimes laminated. The most central portion of the colloid was basophilic, and the more superficial portions were eosinophilic. This colloid was only rarely vacuolated. Medium-sized follicles were occasionally seen, and their colloid sometimes showed the vacuolation associated with resorption. Epithelial size was quite variable; in some of the glands follicles could be seen with high cuboidal or even columnar epithelium. In a few glands epithelial cells were seen that were much larger than characteristic thyroid epithelium. The cytoplasm was pale; the nuclei were large and vacuolated, sometimes rounded, and sometimes multilobular. These cells closely resembled Hürthle cells. Elsewhere in the glands the epithelium was arranged in sheets or clusters of cells with no colloid, rather than in follicles. The stroma was poorly vascularized and contained abundant fibrous tissue, which was sometimes edematous. The parathyroid was free from damage. Although appreciable variability was seen in the thyroid glands of these animals, the group--as a whole--appeared to have little surviving functional thyroid tissue.

* Standard deviation = $\sqrt{N \times p \times q}$, where N is the number of tumors in a group, p is the probability of the tumor's being benign, and q is the probability of the tumor's being malignant.

Pituitary. The pituitary gland showed more variability than the thyroid. The most characteristic appearance was of a gland with a reduced number of acidophils and an increased number of basophils. The acidophils were usually degranulated. The staining reaction of the cytoplasm of the basophils often varied markedly from light to very deeply basophilic. A number of the glands showed enlarged basophils which contained droplets of colloid - the characteristics basophils of thyroid deficiency. Chromophobes were abundant. Chromophobe adenomas were found in a number of the glands. These were circumscribed masses of cells whose cytoplasm was more abundant than in normal chromophobes, and whose nuclei were larger; some cells showed more than one nucleus, and others had multilobular nuclei. Still other glands showed hyperplastic areas containing these chromophobes. There were, on the one extreme, pituitary glands whose structure was within normal limits, and on the other, glands that showed no cell types other than chromophobic. The latter glands often had dilated sinusoids.

Adrenal. The adrenal glands of nearly all the animals in this group showed atrophy of the cortex with disorganization of the architecture, particularly in the zona fasciculata and reticularis. The cells were often small, and had shrunken, deep-staining, almost pyknotic nuclei. Vascularity in these regions was usually poor. Several of the glands contained adenomas, which were occasionally large enough to distort the neighboring cortical tissue. Sometimes hemorrhage and large circumscribed areas of degeneration were seen. A few of the glands were cystic and contained amorphous material. The adrenal medulla was normal. Within the group there were a number of adrenal specimens in which the greatest part of the gland was substantially normal in structure; a few others showed only moderate atrophy.

Ovary. The ovaries were highly variable in their structure, but nearly always showed evidence of markedly disturbed function. Most of them were smaller than the ovaries of normal animals and contained few follicles. Such follicles as were found were very small, or, at best, were only of medium size. The corpora lutea that were seen likewise showed variability; in a few cases their structure suggested recent formation, but generally they appeared to be degenerating. The interstitial tissue was deficient, and the vasculature was poor. Clusters of small tubules were often found in the hilar region. The structure of a few of the ovaries in the group suggested that occasional cycles were still in progress. Ovarian cysts were frequently seen; they were sometimes single and sometimes multilocular. These cysts might be empty or filled with amorphous material, or contain material suggesting hemorrhage and blood resorption. They rarely contained inflammatory material. Two ovarian tumors were encountered. One resembled a granulosa cell tumor and the other an endometrioma.

Uterus. In nearly all the animals the uterus was very small and thin-walled, with a thin endometrium containing few glands and vessels. Cystic changes were sometimes seen in the endometrium, and uterine polyps were found in a considerable number of the animals. These polyps were usually large, but occasionally they were of microscopic dimensions. In some animals very deep clefts in the endometrium possibly represented the earliest stages of polyp formation.

Lung. No lung pathology was seen that was directly attributable to the astatine. Pneumonitis and pneumonia (chronic and acute) were seen in varying degrees in a number of animals. The majority of the lungs were well aerated and showed slight peribronchial infiltration of lymphocytes. Metastases of tumors whose primary site was located elsewhere were observed in two animals.

Liver. The majority of animals showed a liver structure that was within normal limits. It was not uncommon, however, to find areas of cloudy swelling, vacuolar degeneration, atrophy of epithelial cords, or even spotty areas with dying cells. The animals showing such hepatic degeneration usually had a severe pneumonia or lung abscess which could account for the liver damage.

Kidney. The kidneys of the majority of the animals were within normal limits. Many of the specimens showed a substantial amount of golden-brown pigment within the cells of the convoluted tubules. A few showed mild glomerular fibrosis or atrophy, but retained an adequate number of functioning glomeruli. Although rare, cloudy swelling and vacuolar degeneration were encountered.

Lymph Node. The lymph nodes were usually taken from the mesenteric region. Their structure varied from essentially normal to markedly atrophic. Most characteristically, the cortex of the nodes was slightly depleted of lymphocytes, and continued to show nodules, although these had no germinal centers. The medulla usually had a scanty supply of lymphocytes, and the reticular framework was conspicuous. In one instance, a lymph node removed from the mediastinal region of an animal that had a tumor showed a metastasis. A metastasis had also been observed in the lung of this animal.

Spleen. The spleen likewise showed variability in its structure. The red pulp was usually normal, although it often contained a substantial amount of pigment, both intra- and extra-cellular. In some instances the organ was normal or only slightly depleted of white pulp. In a substantial number of animals, however, the white pulp showed a considerable degree of depletion. The Malpighian corpuscles were smaller, and the framework of the spleen was conspicuous. Megakaryocytes were very rarely seen in the spleen in the great majority of animals in this group. There were, however, rare exceptions in which there were appreciable numbers of megakaryocytes. In one case as many as twenty per low-power microscope field were seen.

Thymus. The histologic appearance of the thymus was highly variable. To some extent, this represented the thymic involution commonly seen in older animals. Thymic tissue had often been replaced in varying amounts by developing fat. The residual thymic tissue, in these instances, was normal or only slightly depleted of lymphocytes. The presence or absence of epithelial tissue within the thymus was particularly noteworthy. In the 45 specimens examined, one-third showed no epithelial remains. Another third showed scanty cords or strands of epithelial tissue. Such epithelium was seen only in the lobules that contained lymphocytes, and was never found in the lobules that had undergone fatty transformation. In the remaining third

Durbin and Asling

of the specimens at least part of the epithelium was arranged in small follicles. Some of these follicles possessed droplets of colloid. In four instances the follicles were large enough, and the nature of the colloid was sufficiently distinguishable, to allow recognition of this tissue as aberrant thyroid glandular tissue.³ In two instances, where the epithelial remnants were chiefly cords or strands, the appearance of the cells suggested that they had undergone damage as though by irradiation.

Tumors. Most of the tumors were encountered in regions suggestive of a mammary origin from the axilla along the line corresponding to the embryonic milk line and into the inguinal region. The benign tumors of presumptive mammary origin showed a fairly characteristic pattern. The epithelium was arranged in small ductlike clusters whose cells were fairly well-differentiated columnar epithelium. Amorphous material was, at times, present in the lumen. Between these ductlike structures there was usually a small amount of well-differentiated fibrous connective tissue stroma with a moderately abundant blood supply. Such tumors were designated as adenomas. Other tumors whose structure was mixed epithelial and connective tissue, with the former in preponderance, were designated as fibro-adenomas. Still another group of tumors, with relatively scanty amounts of epithelial tissue and very abundant masses of well-differentiated fibrous tissue, were designated adenofibromas to indicate the preponderance of stroma. In two instances the epithelial tissue had degenerated almost entirely, leaving small pickets or other circumscribed areas which marked the sites where epithelial clusters had once existed. Such tumors were called fibromas in spite of their undoubted original glandular origin. Cystic tumors and intracystic papillomas were also seen. Many of the tumors showed clear evidence of malignancy: (a) their capsules had been broken through; (b) the cells comprising the tumor tissue had become degenerative and anaplastic; (c) mitotic activity (or at times, nuclear hyperchromatism) was observed; or (d) the structure of the tumor tissue was hemorrhagic and degenerative. In some instances evidences of metastatic, either by direct extension into adjacent tissue or by more remote transmission, confirmed the diagnosis of malignancy.

The majority of the malignant tumors were of the carcinoma variety. In some cases the glandular structure persisted, and the tumor was recognizable as an adenocarcinoma. The glandular structure had disappeared in others, and the tumor was a mass of undifferentiated cells all though they were still of epithelial appearance; these were designated as medullary carcinomas. Uncommonly, the epithelium had undergone transformation to squamous cell type, and the tumor contained epithelial pearls, allowing squamous cell carcinoma to be recognized. Tumors were also observed that contained little tissue recognizable as epithelium, and were mostly tissue of presumptive fibrous origin. Such tumors were called sarcomas, fibrosarcomas, and mixed-cell sarcomas; at times, these same tumors contained combinations of the foregoing.

³Asling, Durbin, et al, Evidence for Function of Aberrant Thyroid Tissue in Thymus of Rats, Proc. Soc. Exptl. Biol. Med. 94, 200-201 (1957).

Thyroxine-Pretreated (Group B)

Thyroid. These thyroid glands were slightly less damaged than the controls that had received no thyroxine pretreatment. No completely normal thyroid glands were found. Most of the glands contained small-to-medium-sized follicles whose epithelium seemed slightly higher than in the controls--from low to high cuboid. These follicles sometimes had nearly normal-appearing colloid; at other times the colloid was the dense, deep-staining, laminated material that was seen in Group A. Infrequently, large follicles were encountered which contained colloid that appeared to be undergoing resorption. Elsewhere, there were follicles with a high-cuboid to columnar epithelium whose appearance suggested that they were under stimulation. There were times when this epithelium, because of its height and general appearance of activity, resembled the epithelium seen in the goiters induced experimentally in rats by administration of propylthiouracil. The thyroid epithelium appeared more nearly uniform than in Group A. The large, pale cells resembling Hürthle cells were not seen in as many specimens, and when encountered, they were more sparse than in Group A. The stroma of most of the specimens in this group was normal or slightly reduced in vascularity; in some cases a considerable amount of edema was observed. In one specimen a cystic adenoma of the thyroid gland was identified. This tumor was a circumscribed cluster of follicles lined with a very high basophilic cuboidal epithelium in which the nuclei were larger and more vesicular than in characteristic thyroid epithelium. The colloid in the cysts resembled that of thyroid tissue.

Pituitary. The histological structure of the anterior lobe of the pituitary reflected the slightly better condition of the thyroid glands. Often the anterior pituitary was found to be within normal structural limits, suggesting that the thyroids, although damaged, were producing enough hormone to support normal pituitary morphology. In some of the specimens the acidophils were reduced in number or granular content. The number of basophils was slightly increased. The enlarged colloid-filled basophils characteristic of thyroid deficiency, however, were seen relatively rarely in this group. In a few instances pituitary glands were seen which showed the typical picture of thyroid deficiency: the majority of the acidophils were degranulated, the basophils were substantially increased in number, and thyroid-deficiency basophils were present. Chromophobe adenomas were not encountered in this group so often as in Group A.

Adrenal. The adrenal cortex was close to normal width in this group, and the arrangement of its cells into zones was nearly normal. Sometimes cells within such relatively healthy-appearing adrenals had an atrophic appearance: small, with scanty cytoplasm, and shrunken and very dense-staining nuclei. Vascularity was slightly reduced in many instances. In a few cases the cortex was thinned, and its architecture was disorganized. Its cells were sometimes atrophic, particularly in circumscribed regions. Some islands of degeneration and hemorrhage were encountered. Several specimens showed well-circumscribed adrenal cortical adenomas.

Durbin and Asling

Ovary. The structure of the ovaries suggested that some ovarian function had been maintained in many of the animals of this group. Medium-sized to large follicles were found; often they were well vascularized. Many of the glands had well-developed corpora lutea. The general appearance of the interstitial tissue was within normal limits. As in the adrenals, there were some ovaries whose structure reflected a hormonal deficiency. Such ovaries often had no follicles, poor corpora lutea, and deficient interstitial tissue.

Uterus. The uterus of the animals in this group reflected the variability of ovarian functional adequacy; some had well-developed muscular walls and endometrium, while other (though in the minority) showed evidences of deficient hormonal supply.

Lung. The lungs of these animals were usually normal and well aerated. Pneumonitis, pneumonia, and lung abscesses were encountered much less frequently than in Group A. In one animal the lung contained a primary tumor. The tumor was poorly circumscribed and was invading the adjacent lung tissue. It consisted of sheets and hollow clusters of cells of a very high columnar epithelium with a scanty stroma. Many of the nuclei were hyperchromatic, and mitotic activity was found. This animal also had a tumor of mammary origin that was clearly benign and showed a structure substantially different from the lung tumor. The lung tumor was therefore believed to be a carcinoma, having its origin in the lung, probably from the bronchial epithelium, and not a metastasis from the mammary tumor.

Liver. The structure of most livers was not normal. Occasionally a mild cloudy swelling was seen. In animals with appreciable lung disorder, vacuolar degeneration was occasionally seen.

Kidney. Virtually all the kidneys were within normal limits, although a few showed slight cortical atrophy or minor glomerular fibrosis. Pigment was not encountered so often in the kidneys as it was in the preceding group.

Lymph Node. The lymph nodes were nearly all of normal appearance. A few were slightly depleted of lymphocytes. One node from an animal with a medullary carcinoma (presumably of mammary origin) showed a metastasis of this tumor, while a node from another tumor-bearing animal contained what may also have been metastatic tissue.

Spleen. The majority of spleen specimens were within normal limits. In some instances the white pulp was slightly or moderately depleted, but the red pulp continued to be normal. Pigmentation was generally less conspicuous in this group than in the preceding. On the other hand, megakaryocytes were found in a fair porportion of the specimens, although seldom in large numbers in any single section.

Thymus. The thymus gland was usually normal or nearly so. Thymic involution was not so common as in Group A, although a few specimens had undergone almost complete transformation to developing fat. A few others showed slight depletion of the lymphocytes. About 80% of the specimens

contained some epithelial tissue. However, this was not usually arranged into the well-developed follicles resembling thyroid gland, as in Group A. In half the animals only epithelial strands or sheets were seen. And at best, these cells were clustered into rosettes or very tiny follicular arrangements without a colloid content. In a small minority of the specimens recognizable thyroid follicles were found.

Tumors. The tumors encountered in this group of animals were of much the same kinds as in Group A. The majority were of recognizable mammary origin, and tended to remain benign. In some animals multiple tumors were encountered; for example, one animal bore a cystic adenoma of mammary tissue, an adenocarcinoma of the same origin, and a squamous cell epithelioma of Grade I malignancy in the uterus. In one instance, what must once have been an adenocarcinoma of mammary origin appeared to have lost its malignant character, and showed only degenerated remnants of epithelium buried in very dense collagenous fibrous tissue. It may be noted that in the tumors seen in this group, epithelium usually predominated, and the amount of fibrous tissue in the benign tumors was seldom abundant. Similarly, tumors showing a clearly sarcomatous character were less commonly seen.

Thyroxine Therapy (Group C)

Thyroid. The thyroid glands showed a marked degree of destruction. Many were composed almost entirely of fibrous tissue in which a few single epithelial cells or small cell nests were seen. In some the gland was composed of tiny follicles, most of them without colloid. Their cells were usually cuboidal. Elsewhere, slightly larger follicles could be found containing scanty amounts of dense, deep-staining colloid. Giant cells resembling Hürthle cells appeared in a high proportion of these specimens, although they were seldom in large numbers. An appreciable degree of variation in cell size was encountered. Generally, the stroma was poorly vascularized. Areas suggestive of residual function were quite rare.

Pituitary. Although a few of the pituitary glands showed nearly normal structure, most of them showed reduced numbers or degranulation of the acidophils and a substantial increase in the number of basophils. In only a few instances, however, were thyroid-deficiency-type basophils to be seen. Some of the glands were almost completely chromophobic. In only one of the 16 specimens was an easily recognizable chromophobe adenoma found--and that was very small. In two others, small, partially circumscribed areas suggestive of an adenoma were seen.

Adrenal. Adrenal structure was variable in the group. The most characteristic structure was that in which cortical width and integrity varied within the gland. Thus, regions could be found with a wide cortex and reasonably normal architecture. Other areas of narrowing and distortion of cortical architecture, often with circumscribed islands of cellular degeneration, could be found interspersed with the normal areas.

Durbin and Asling

Ovary. Ovarian structure was almost invariably defective. Most ovaries showed degenerating corpora lutea and deficient interstitial tissue. Developing follicles were very rare. Cysts were encountered with much greater frequency in this group than in Group A or Group B, and these cysts sometimes showed hemorrhagic or inflammatory changes.

Uterus. In the uterus the endometrium was frequently thin, with a reduced number of glands and blood vessels. Polyps were numerous, and deep infoldings of the endometrium, suggesting beginning polyps, were particularly common.

Lung. The lungs frequently showed acute and chronic pneumonitis or pneumonia. Abscesses were occasionally encountered. Only one-third of the group possessed normal lungs.

Liver. The liver was often damaged. Cloudy swelling, vacuolar degeneration, and small islands of atrophic or even necrotic hepatic cells were frequently encountered, which probably reflected the pneumonic or degenerative processes elsewhere in the body.

Kidney. The kidneys were generally within normal limits of structure, although occasionally fibrotic or avascular, scarred glomeruli were found. In one animal in which a malignant tumor of mammary origin had been recognized, there was a metastatic patch of tumor on a pole of the kidney near the pelvis. The patch consisted of sheets and masses of ductlike epithelium invading the renal stroma and pushing the tubules aside. The cells were deeply basophilic; in some areas they were very anaplastic. This tumor mass was more highly differentiated than the primary tumor in the mammary region.

Lymph Node. There was considerable variability in the structure of the lymph nodes. The majority showed a substantial depletion of lymphocytes and reduced lymphopoietic centers. A few glands had nearly normal structure, with well-developed follicles; in some cases germinal centers were seen in the cortex of the nodes.

Spleen. In the spleen, as in the lymph nodes, the white pulp was sometimes only slightly depleted. It showed more frequently a moderate reduction in lymphopoiesis. The red pulp was often engorged and contained a heavy deposit of golden-brown pigment in the sinusoids and in the cells of the splenic framework. With a few exceptions, megakaryocytes were quite rare in the spleen specimens in this group.

Thymus. The thymi of several of the animals showed a considerable degree of involution and replacement by developing fat tissue. Those glands which still contained lymphatic tissue showed little lymphocyte depletion. Epithelial remnants were lacking in half the specimens of thymus examined. In the other half epithelial strands and cords were seen, and they were often associated with a few small clusters organized into follicles. These contained colloid and were generally recognizable as of thyroid character. A large mass

of true thyroid tissue was seen in one instance. In fact, its structure was more typical than any of the actual thyroid glands examined in this experiment.

Tumors. Tumors taken from the animals in this group had much the same distribution of types as in the preceding groups. The incidence of malignancy was not so high as in the controls. It was again noteworthy that epithelial tissues predominated in this group. The benign tumors were substantially adenomatous and seldom had abundant fibrous mass. Only one fibroma was seen. Similarly, the malignant tumors were always of the carcinoma variety, and no sarcomata were diagnosed. Generally, the differentiation of epithelial cells was moderately well maintained in the carcinomata. Degeneration and anaplastic change were less conspicuous than in preceding groups.

RADIATION CHEMISTRY

Warren M. Garrison in charge

Boyd Weeks, Michael Jayko, Winifred Bennett,
Sibyl Cole, and Margery A. Andrews

PROTEIN

The study of protein oxidation by OH radicals in aqueous solution has been extended to include the oxidation of gelatin by Fenton's reagent. The reaction $\text{Fe}^{+2} + \text{H}_2\text{O}_2 \longrightarrow \text{Fe}^{+3} + \text{OH}^- + \text{OH}$ produces OH radicals chemically. The use of this reaction has enabled us to isolate and identify (from the protein hydrolysate) carbonyl acids formed in agreement with the mechanism proposed previously for the radiation-induced oxidation of diethylamine. The oxidation of gelatin by Fenton's reagent, followed by dialysis and hydrolysis in vacuo by 4N HCL has resulted in the identification by paper chromatography of three keto acids: glyoxylic, pyruvic, and α -keto glutaric. These are derived from glycine, alanine, and glutamic acids respectively, and are released from the peptide chain on hydrolysis.

We have shown in a series of control experiments that gelatin, dialyzed in the presence of a keto acid like glyoxylic acid, does not irreversibly absorb the acid. Hydrolysis of the protein, under the conditions used, does not oxidize amino acids to keto acids in amounts sufficient for detection. The same is true for the possible oxidation of glycine and alanine by ferric ion. These experiments confirm the presence of large carbonyl-containing molecules as products of OH oxidation, and demonstrate the absence of secondary reactions that could give rise to carbonyl acids.

Experiments with irradiated pepsin solutions have demonstrated that the hydrazones obtained on treatment with 2,4-dinitrophenylhydrazine are not removed during dialysis. Hydrogen peroxide at concentrations accumulating in the target cell during irradiation is not able to oxidize pepsin. Procedures in which the sequence of heat precipitation, dialysis, addition of 2,4-dinitrophenylhydrazine, etc. is altered do not affect the results. The hydrazone absorption curves clearly show the separation of mono- and di-carbonyls in the heat-precipitated nondialyzable material. Thus far, isolation of specific compounds from irradiated pepsin has not been possible because of several technical difficulties, one of which is the low solubility of pepsin in water. Large volumes are necessary to accumulate sufficient product for identification. Work of this nature is being undertaken at the present time.¹

From the point of view of radiation biology the most significant aspect of this work is the low level of radiation that can be accurately followed in establishing the center of the initial radiation-induced reaction. By use of the same basic techniques developed for these studies, the radiation chemistry of carbonyl formation in a variety of biological systems can be studied.

¹Biology and Medicine Quarterly Report, UCRL-3758, April 1957, p. 27

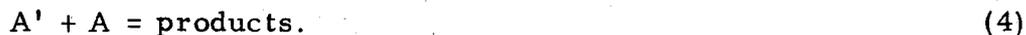
The application of these procedures in a preliminary study of rat liver homogenate has been described in a previous Quarterly Report.¹

EFFECTS OF DOSE RATE IN THE RADIOLYSIS OF AQUO-ORGANIC SYSTEMS

Information on the nature of the organic free-radical intermediates formed in the radiolysis of aquo-organic systems can often be deduced from studies of product formation as a function of dose rate. For example, in the radiolysis of an aqueous solution of the compound A, we may have the reactions



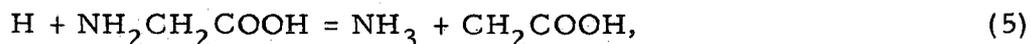
followed by competing processes of the type



The observed yields of final products may depend on the relative rates of Reactions (3) and (4). The radical-combination reactions corresponding to Eq. (3) would be favored over reactions of type (4) at high-dose rates. If Reaction (3) leads to a dimer or other high-molecular-weight product, it is possible to obtain detailed information on the properties of the intermediate A'.

The cyclotron provides a versatile source for studies of this kind. The high-dose-rate condition is readily obtained with the beams of protons, deuterons, and helium ions that are available at energies of 12 Mev per nucleon. For protons, the target geometry is such that the beam energy is absorbed in a volume element of less than 0.05 ml. Cyclotron irradiations at low-energy-input values (per ml) can be made through recoil nuclei formed on exposure of the aqueous system in the fast-neutron flux obtained by bombardment of beryllium with 24-Mev deuterons. The dosimetry relationships and target geometries for both conditions have recently been described.²

Evidence for dose-rate effects in the radiolysis of aqueous glycine solutions was presented in previous reports.^{3,4} In this system H and OH are removed via



Under the condition of high radical concentration obtained in irradiations with 40-Mev helium ions, it was found that the radical-radical reactions involving CH_2COOH and NH_2CHCOOH result in the production of succinic acid and aminosuccinic acid. At lower radical concentrations the CH_2COOH radicals

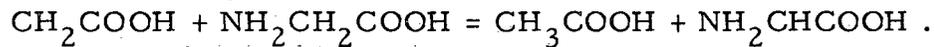
¹Biology and Medicine Quarterly Report, UCRL-3758, April 1957, p. 27

²Garrison, Weeks, Ward, and Bennett, J. Chem. Phys., in press.

³Boyd M. Weeks, Indirect and Direct Action of Heavy-Particle Radiation on Glycine in Aqueous Solution UCRL-3071, (Thesis), July 1955.

⁴W. M. Garrison and B. M. Weeks, J. Chem. Phys. 24, 616 (1956).
Garrison

are preferentially removed via

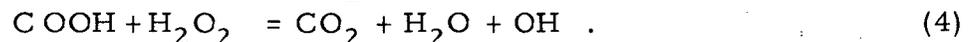
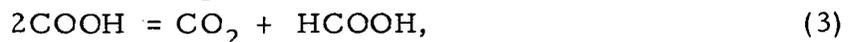
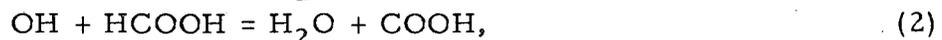
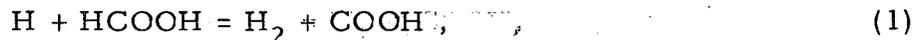
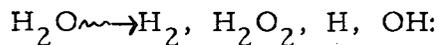


Dose-rate effects have also been observed in radiolysis studies of aqueous formic and acetic acids. Some of these results are treated in the sections on radiolysis of formic acid and acetic acid.

An interesting aspect of the dose-rate effect is its possible use in establishing the locus of H and OH attack on complex molecules of direct biological interest. Consider an oxygen-free solution containing protein molecules P, and a simple organic solute, A. Reaction of water radicals with P and A would yield the radicals P' and A'. Regardless of other considerations a high radical concentration would favor the combination reaction $\text{P}' + \text{A}' = \text{product}$. If A were $\text{C}^{14}\text{H}_3\text{COOH}$, it follows that the product compound $\text{P}-\text{C}^{14}\text{H}_2\text{COOH}$ on hydrolysis would yield a C^{14} -labeled species that would provide information regarding the configuration of the protein radical P'. Studies of this type are being initiated.

RADIATION-INDUCED SYNTHESIS OF HIGHER-MOLECULAR-WEIGHT COMPOUNDS FROM FORMIC ACID IN AQUEOUS SOLUTIONS

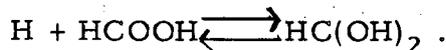
It has been shown that irradiation of dilute oxygen-free formic acid solutions with cyclotron-produced helium ions results in the formation of higher organic acids and carbonyl compounds. Both glyoxal and glyoxylic acid, together with smaller amounts of oxalic, glycolic, tartronic, mesoxalic, and tartaric acids, are formed at radiation doses that correspond to the removal of less than 1% of the formic acid initially present in the target solutions. In interpreting these data it was pointed out that the synthesis of high-molecular-weight products at pH values below 3 seemed to be characteristic of reactions that were favored at the high radical concentrations obtained with the cyclotron beam.⁵ Gas-yield data obtained by Hart in x-ray radiolysis studies of the same system indicate that high-molecular-weight products are not formed at lower radical concentrations.⁶ The x-ray data were quantitatively explained by Hart in terms of the sequence



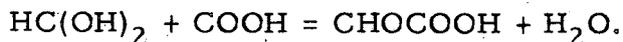
⁵Garrison, Bennett, and Jayko, J. Chem. Phys. 24, 631 (1956).

⁶E. J. Hart, J. Phys. Chem. 56, 594 (1952).

On the basis of the above considerations we proposed that the results of both irradiation conditions could be explained on the assumption that H adds reversibly to formic acid according to

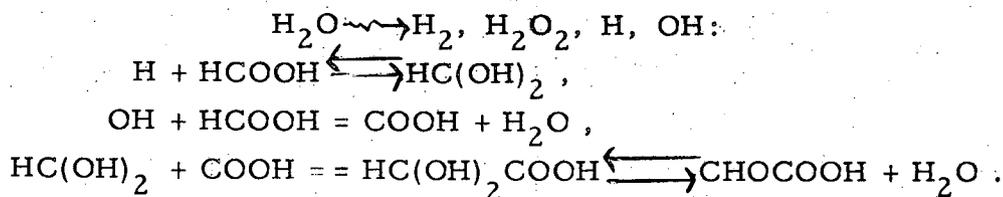


If Reaction (2) above is fast compared with (1), then the reduced formic acid radical $HC(OH)_2$ could combine with $COOH$ to give glyoxylic acid at the radical concentrations attained in irradiations with cyclotron beams, i. e.,



In the γ -ray study the radical concentrations are lower, and H would be preferentially removed via Eq. (1).

We have confirmed these experimental findings in a series of irradiation studies in which the yields of organic products from formic acid have been determined for proton and helium-ion beams, and for recoil nuclei produced by neutron bombardment (see the preceding section on Effects of Dose Rate). The irradiation procedures and the analytical techniques based on the use of $HC^{14}OOH$ have been described. Typical data are summarized in Table II. It is seen that higher-molecular-weight products are not produced in appreciable yield in the neutron irradiations. The radical concentrations in this case approximated those of the x-ray experiments reported by Hart. The proton and helium-ion data, on the other hand, show (a) that higher acids are formed under the conditions obtained in beam irradiations, (b) that the yields of these products are essentially independent of dose up to 0.001 μ hr, and (c) that oxalic acid is not an important intermediate in the formation of glyoxylic acid. The principal product relationships observed in Table II can be explained on the basis of the following reactions:



A more detailed discussion of this work, including a consideration of mechanism in the formation of all observed products, is being prepared as a separate report.

⁷ Biology and Medicine Quarterly Reports, UCRL-3208, Oct. 1955; UCRL-3758, April 1957.

Table II

Organic acid yields in the radiolysis of oxygen-free formic acid solutions

Solution	Radiation ^b	Dose (ev)	Product yields (molecules/100 ev) ^a				
			CHCOOH	COHCOCOOH	(COOH) ₂	CH ₂ OHCOOH	COHCHOHCOOH
0.25 N HCOOH	40-Mev He ⁺⁺	1.2 x 10 ²⁰	0.23	0.15	0.082	0.017	0.042
0.25 N HCOOH	40-Mev He ⁺⁺	4 x 10 ²⁰	0.24	0.23	0.088	0.014	0.042
0.03 N HCOOH	40-Mev He ⁺⁺	4 x 10 ²⁰	0.10	- ^c	0.11	0.011	0.040
0.25 N HCOOH	10-Mev H ⁺	1.2 x 10 ²⁰	0.17	0.50	0.17	0.030	0.092
0.25 N HCOOH	neutrons	1.2 x 10 ²⁰	<0.05	<0.01	<0.01	<0.005	<0.005

^aThe reported yields represent the average value obtained from at least two separate irradiations.^bThe proton and helium irradiations were made at a beam current of 0.010 microampere.^cNot determined.

RADIATION-INDUCED OXIDATION OF ACETIC ACID
IN OXYGENATED SOLUTION

The formation of oxalic, glyoxylic, and glycolic acids in the radiolysis of oxygenated acetic acid by 40 Mev helium ions has been previously reported.⁸ In the attempt to establish the mechanism of the reaction, it became apparent that complete removal of primary H and OH radicals was not being effected by the solutes even at helium-ion-beam currents as low as 0.010 μ a. Subsequent studies with the formic acid-oxygen dosimeter confirmed this conclusion.⁵ However, later studies with proton beams showed that complete removal of H and OH is realized at beam currents up to 0.050 μ a. Quantitative yields for the acetic acid-oxygen system have since been obtained for 10-Mev protons and for recoil nuclei formed on exposure of the aqueous system to fast neutrons. Typical data are summarized in Table III. The experimental procedures were those reported earlier.⁸ The proton data can be shown to be consistent with the previously described mechanism, in which formation of the acid products is explained in terms of a parallel series of reactions initiated by the formation of the common precursor, O_2CH_2COOH . The decrease in the ratio of yield of glyoxylic acid to yield of glycolic acid observed with neutrons is of interest in that it indicates an effect of radical concentration on yields that was postulated in the earlier study. If this result is confirmed, it would mean that considerably more basic information could be obtained on the chemistry of the peroxy radicals in this and other systems. The work is being continued.

⁸Herman R. Haymond, Some Effects of Dissolved Oxygen on the Heavy-Particle Irradiation of Aqueous Acetic Acid (Thesis), UCRL-2697, Sept. 1954; Garrison, Haymond, Bennett, and Cole, *J. Chem. Phys.* 25, 11282 (1956).

Table III

Product yields in the radiolysis of oxygen-saturated acetic acid solutions

Solution	Radiation ^b	Dose (ev)	Product yields (molecules/100 ev) ^a			
			CH ₃ COOH	CH ₂ OHCOOH	(COOH) ₂	CH ₂ O
0.25 N CH ₃ COOH	10-Mev H ⁺	1.2 x 10 ²⁰	0.95	0.27	0.35	0.22
0.25 N CH ₃ COOH	10-Mev H ⁺	1.2 x 10 ²⁰	1.0	0.26	0.31	0.30
0.25 N CH ₃ COOH	neutrons	1.2 x 10 ²⁰	0.40	0.41	~0.1	-- ^c

^aThe reported yields represent the average value of at least two separate determinations.^bThe proton irradiations were made at a beam current of 0.010 microampere.^cNot determined.

BIOLOGICAL STUDIES OF RADIATION EFFECTS

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

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

RADIOBIOLOGICAL STUDIES

C. A. Tobias

This program includes investigations on biological samples of various levels of organization, from subcellular to mammalian. The work covered in this report pertains to back-mutation studies of irradiated yeast, studies of hypothalamic-irradiated rats, wasp egg hatching after irradiation, and radiation recovery in Chlamydomonas.

Back Mutations of
S. Cerevisiae Mutants Induced by Ultraviolet- and X-Irradiation

From 12 haploid mutants of S. cerevisiae requiring various amino acids for growth, isoallelic diploids were prepared, isolated, and tested. From this group three auxotrophs were found that gave relatively high mutation rates back to the wild type, for both the cytochrome positive and negative forms, after irradiation with x-rays or ultraviolet. Further quantitative work is being concentrated on these three types.

The rate of reversion of these mutant cells after x-irradiation to normal wild cells appears to be approximately an exponential function of the dose, at least up to doses of 30 r. At 30 r the reversion rate is about 0.003%. With uv irradiation the reversion rate reaches a maximum for doses of 2×10^5 ergs/cm², with a value of about 0.01%. An effect of cytochrome content on radiation sensitivity and irradiation-induced reversion has been detected and is being measured.

It is proposed to extend this work to include study of the effect of temperature and chemical environment on reversion.

Irradiation of Rat Brains with High-Energy Deuterons

The program of irradiating the brains of animals with cyclotron deuterons has had the following objectives: (a) To determine if localized lesions can be made in the brain (especially in the hypothalamus) by this nonsurgical method; (b) to continue the mapping of the hypothalamus (previously done by stereotaxes), if such lesions can be produced; (c) to investigate the possibilities of regulating the neural control of the endocrine system. Object (a) has been demonstrated affirmatively in dogs and rats, and work is continuing on (b) and (c).

Approximately 500 male rats and their controls have been involved in the present study. Irradiation by 190-Mev deuterons was given, primarily to the hypothalamus, through circular and semicircular apertures of 1/8- to 1/16-in. Systematic microscopic examination of serial sections of the brains of these animals has been completed, with the following results:

- a. A region of rather well-defined damage is noted, apparently caused by direct interaction with the beam.
- b. The region of (a) is sometimes smaller than the beam area, suggestive of possible parenchymal radioresistance.
- c. A surrounding region of less well-defined damage is often noted, presumably caused by vascular extension of the primary damage.

The total damaged volume ranges from 0.4 to 5.6 mm³, and appears to be an approximate linear function of the dose. The neural damage seen and its time of appearance have been correlated with the dose, aperture area, and region irradiated. Investigation is continuing on the relation between these factors and in vivo physiologic and metabolic studies made previously on these animals.

In the mapping of the hypothalamic region, centers have been located that regulate the gonadotropin and food intake, confirming earlier results obtained by use of other methods.

THE EFFECT OF X-RAYS ON EGG HATCH AND
EGG-LAYING IN A WASP (MORMONIELLA)

Donald J. Fluke

An egg-hatch test for Mormoniella has been developed and applied to a study of phases of radiosensitivity in oögenesis in this animal. Mormoniella wasps parasitize the pupal stage of blow-flies, feeding on the fly pupa through holes which they pierce in the hard-shelled puparia of the flies, and laying their eggs through these holes on the pupae inside. It has been found possible to break open the pupa cases, extricate the pupae, and transfer the wasp eggs to an agar surface by needle. Egg collection is more difficult than with Habrobracon wasps, and there is less certainty of getting a complete egg inventory, but the eggs of untreated unmated animals hatch with about 90% efficiency on an agar surface.

Mature Animals. The hatch test was first applied to studying phases of radiosensitivity in the eggs of mature animals that had previously actively fed and oviposited. Such animals were starved for varying lengths of time, as with Habrobracon, and after being x-rayed were again allowed to feed and oviposit. The wasps were transferred to fresh host pupae at intervals of 3 to 12 hours over a period of days until they died or ceased to produce eggs, and the various lots of eggs were collected, counted, and tested for hatch. A group of about 30 eggs per wasp was found in an initial sensitive phase, comparable to Metaphase I in Habrobracon or to stage 14 (of R. C. King) in Drosophila. The number in this phase increases somewhat with 10 hours' starvation prior to receiving the x-ray dose, and is much larger than for the comparable phase in Habrobracon. After laying out these eggs, the mature animal produces more than 100 eggs in a stage of intermediate sensitivity not correlated with the resistant phases in either Habrobracon or Drosophila. The hatch never recovers to a more resistant phase before oviposition ceases.

Younger Animals. Since previous work has shown an LET (linear energy transfer) dependence for the resistant phase of Habrobracon, a search for such a phase in Mormoniella was made by irradiating younger animals. Animals irradiated after eclosion but before first feeding do show a resistant phase after laying about 100 to 120 eggs. Roughly the first 20 of these are in the sensitive phase and the rest in an intermediate phase.

Pupae. In Mormoniella the pupal stages are easily sorted out and handled. When mature pupae were irradiated it was found that the resistant phase in eggs laid by the resultant wasp was reached after only about 30 or 40 eggs, but the wasp very soon afterward stopped laying eggs, and at successively earlier times with increasing dose. As earlier pupal stages were irradiated the onset of resistant eggs was still earlier in the sequence, and the effect on oviposition became more pronounced. There appear to be three compartments with respect to hatch radiosensitivity in this wasp, and when examined at various stages of maturation of the animals they do not seem to be of constant size or to be filled in serial order. The effect on oviposition appears more as an independent effect of the radiation rather than as a fourth compartment.

Fluke

At present it is not clear whether any stage will be found in which careful study of the resistant phase is possible. The possibility of conveniently working during different pupal phases in the animal makes experiments with O_2 effects attractive, not only for egg hatch and dominant lethals, but also for recessive lethals, by the technique of Heidental for Habrobracon.

RATE OF FORMATION OF LYMPHOCYTES

Lola S. Kelly

The rate of formation of lymphocytes has been estimated in rats, guinea pigs, and mice by measuring the DNA content and DNA turnover time of lymphatic tissue. This rate of formation, when combined with lymphocyte life-span measurements, will enable one to calculate the size of the extravascular lymphocyte pool. Preliminary estimates make it clear that this pool must be very large compared with the number in the circulation.

The DNA turnover times were measured, with P^{32} as the tracer and with the specific activity of the acid-soluble phosphates assumed as the precursor specific activity. All visible lymphoid tissues (with the exception of Peyer's patches) were included in the sample. In the rat experiments thymus was measured separately. The turnover times were as follows: guinea pigs, 45 hours; mice, 93 hours; rats, 60 hours; rat thymus, 43 hours. From these turnover times and the total DNA content, it can be calculated that the number of lymphocytes produced per hour in lymphoid tissue is approximately the same as the number circulating in the blood. This is a minimum value, since it does not include lymphocytes produced in the spleen and in very small scattered lymphoid nodules.

STUDIES ON THE EMBRYONIC NUCLEOPROTEIN
FRACTION THAT STIMULATES GROWTH IN TISSUE CULTURE

Roman J. Kutsky

Work was continued on isolation and characterization of the biologically active components of the nucleoprotein fraction of chick embryos that stimulates intense growth in tissue culture. A method was found to split off the nucleic acids from the nucleoprotein fraction, leaving the protein fraction in an undenatured form. This protein fraction was found to be the carrier of the biological activity, whereas the split nucleic acids were inactive in tissue culture. When the active protein fraction is examined in the analytical ultracentrifuge and electrophoresis apparatus by Dr. Thomas Davis it appears to be an essentially homogeneous entity at the pH used in tissue culture. Chemical analysis by courtesy of Dr. Norman K. Freeman has disclosed the protein fraction to be a lipoprotein containing about 4% lipids. These lipids are being tested in tissue culture. Biological activity of this protein fraction is lost at pH 11, but no other changes in physicochemical properties have been noted in the PF at pH 11.

Work on adult nucleoproteins with Dr. Morgan Harris has shown that NPF's can be obtained from adult mammalian (rat) tissue in yields comparable to those from embryonic and adult chicken tissues. These rat NPF's have been shown to stimulate growth of chick cells in tissue culture. Biologically active protein fractions have also been obtained from adult tissue NPF's in a manner similar to that used for embryonic NPF.

REPORT ISSUED

A report by Baruch S. Jacobson, Evidence for Recovery from X-Ray Damage in Chlamydomonas, is to be issued as UCRL-3893, Aug. 1957.

RADIATION DETECTION AND PROTECTION

Radiation Laboratory
University of California
Berkeley, California

HEALTH CHEMISTRY

Nelson B. Garden in charge

Reported by Rosemary J. Barrett

BUILDING AND REMODELING

The remodeling of certain portions of Old Chemistry Building required demolition of Room 308, permanently sealed off since about 1943 because of Po^{210} contamination. Because of health and technical hazards within this area, close radiological safety supervision was required, and special handling and disposal techniques were invoked during the removal of large objects, such as construction materials. A tight control of airborne activity was mandatory, and despite the presence of a large quantity of Po^{210} in the form of dry dust, so easily released during such gross operations as the dismembering of structural objects, the control techniques of prepainting and papering were so successful that an air-sample summary showed that there were but three out of 47 work periods during which alpha-emitter concentration exceeded 1% of the maximum permissible concentration, and none reached 5%. Two hundred and twenty-five drums of concreted waste, plus numerous large packages of equipment and building members, were made ready for sea disposal. Health Chemistry members and the nonproject U. C. campus safety group, Radiological Safety, cooperated in this project.

The Health Chemistry air-sampling counting operations were moved permanently to Room 109, Bldg. 4, Health Chemistry's newly created low-level counting area. A location on the first floor of Bldg. 4 was chosen for the site of low-level counting in order to take advantage of natural protection from the sporadic electrical influence of the synchrotron, some 200 feet away, which tended to make counting on the second floor erratic.

Health Chemistry's decontamination facilities in Room 105, Bldg. 5, replacing the decontamination space in Bldg. 70 relinquished to research projects, have been completed. Badly needed storage space was created by remodeling the little-used mezzanine in this room.

Design criteria have been established for hoods and manifolds in the new laboratory facility to be constructed in Room 153, Bldg. 70.

APPARATUS AND EQUIPMENT

Further study is being made on the improvement of the radioactivity-covered plaques for use in intracavity insertion in the treatment of cancer in humans (see Preceding Quarterly Report). A promising sample has been provided through use of ceramic carriers for Cs^{137} , the radioactive material currently being used, and a copper-foil overglaze to the ceramic plaque is being tested.

A target equipment cart, comprising a mobile laboratory, was designed and fabricated and put to use by the Chemistry group for transportation of radioactive targets of the level of 10^3 dpm from the hilac and 60-in. cyclotron to Bldg. 70. The mobile facility includes counting equipment.

Enclosures and auxiliary equipment were provided during this quarter as follows:

Thirty-six gloved or manipulator boxes fabricated and fitted, or re-worked, for such projects as

Classwork demonstrations of the irradiation of yeast cultures by Po^{210} , for Medical Physics;

Donner Clinic's P^{32} preparation box, whereon an additional door for prevention of dust accumulation and a new glove port for easier change of worn gauntlets were added;

A microspectrometer enclosure for Room 260, Donner Annex;

Boxes for Pu (lead shielded), irradiated U^{238} (lead shielded), irradiated Th (lead shielded), U^{235} , and At^{211} chemistry;

For the atomic beam people, an enclosure for working with 10-mC amounts of I^{131} , for the production of elemental iodine (glassware used in this work is too large for the standard gloved box); requisite shielding on front of box provided; studies on gaseous I^{131} (and its compounds) arising from atomic-beam vacuum pump effluent continued;

An enclosure for sandblasting beryllium, and gloved-box enclosures for inert-gas-envelope welding of beryllium, performed in the shops of Bldg. 4;

A cupboard, exhausted by blower via filter and duct into near-by hood, to be used to house active micropipettes stored in aqua regia to effect cleaning (acid fumes, possible spillage, and contamination were actual and potential problems when these items were stored in beakers on bench tops);

Plastic skin replacement on Bio-Organic Chemistry Group's inert-atmosphere gloved box;

A box for the Richmond Field Station for use in the S^{35} labeling of compounds associated with sewage-treatment plants, ventilation equipment included;

Garden

A setup for use with the permanent-magnet alpha spectrometer: two standard boxes joined by interchange, used for mounting of 10^{12} cpm Cm^{242} (also Cm^{244} and Pu^{238}) on 0.010-in. platinum wire in a camera, which is then loaded with film and placed in a vacuum tank in a magnetic field; a box for use in developing films, with necessary ventilation features, also provided;

A ventilated storage box for tritium targets used in the linear accelerator; and Equipment for transferring an alpha-emitter-laden inert-atmosphere box from one "piano box" to another, including provision of adequate support for inert box in new location, plus ventilation and control of airborne contamination during move.

A new motor housing and changes to the power source for use with tong stirrers were developed, the former motors having been observed to develop a tendency to bind after disuse; several motor types were tested in order to make the optimum choice, and a new stock has been established.

In the preceding Quarterly Report, it was stated that the specially fabricated Sr^{90} sources (made to specification by Health Chemistry over the last eight-odd years) were recalled, owing to a failure of one source's aluminum foil window due to premature corrosion. These sources have been reissued in three styles--with windows made of mica, of aluminum, and of mylar; the new sources will of course be inspected frequently. The intensity of bremsstrahlung present, largely brought on by the presence of certain metals such as platinum, in the old-style Sr^{90} "guns" has been materially reduced through the use of carbon plating disks and aluminum inner parts. Thirteen Sr^{90} sources, whose strengths vary from microcuries to 5 millicuries, have been issued during this quarter.

Other sources fabricated on special request by Health Chemistry's Special Problems group include five Po^{210} 's, seven Cs^{137} 's, one Am^{241} , two Pu^{238} 's, three Co^{60} 's, and nine miscellaneous meter standards.

MISCELLANEOUS

Further improvements in the use of adsorptive media for emanation have been effected.

Five environmental air samplers requiring no electrical power were placed around the Berkeley site, with one in Napa Valley as a control.

In addition to the current quantities of waste, the backlog of 1600 gallons of active liquid waste, mentioned first in an earlier Quarterly Report, UCRL-3573, has been solidified through the addition of a cement-vermiculite mixture as a gelling agent and has been consigned to sea disposal.

Two members of Health Chemistry participated in a preliminary radiological survey in selected areas off the coast of California conducted by the Scripps Institution of Oceanography. The survey was made in order to establish

Garden

that no gross contamination could be found in the vicinity of the radioactive waste burial area. A full report on this survey is in preparation and it is expected that an evaluation to very low levels will be worked out at a future date.

HEALTH PHYSICS

Burton J. Moyer in charge

STATISTICAL SUMMARY OF MONITORING PROGRAM

Survey Instruments Maintained

Beta-gamma meters	22
IDL meters	21
Juno ion chamber	20
Abacus logarithmic ion chamber	30
Recording-intensity meters	8
Victoreen proteximeter	3
Slow-neutron proportional counters	15
Fast-neutron proportional counters (portable)	11
Slow-neutron portable unit	4
Balanced chamber--fast neutron--portable	3
Special tissue wall survey instrument	1

Survey Instruments in Storage

Beta-gamma meters	7
-----------------------------	---

Personnel Meters in Use--Berkeley Only

Total personnel covered with film badges	2000
Total man-days' coverage with electrosopes	5400
Total man-days' coverage with dosimeters	2700
Total man-days' coverage with slow-neutron chambers	2700

	<u>Man-days</u>	<u>Number per day (approximate) for 3 months</u>
<u>Bevatron</u>		
Electrosopes	1360	15
<u>Bldgs. 10, 53, and 80</u>		
Slow-neutron chambers	1800	20
Dosimeters	1800	20
Electrosopes	1800	20
<u>Grocker</u>		
Slow-neutron chambers	900	10
Dosimeters	900	10
Electrosopes	900	15

Moyer

Bldg. 70

Electroscopes

1360

15

Cases of Weekly Exposure Above 0.3r*

Weekly film expos. above	184-inch area	60-inch area	Linac	Chem	Other	Total
0.3	1	2	25	1	4	33
0.5	0	0	3	1	1	5
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
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

He³ SPECTROMETER FILLING SYSTEM

This past week has seen the completion of the shop's portion of the He³ spectrometer filling system, including an over-all vacuum check. Prior to this, the main impediment to completion has been faulty trap material. Soldered copper traps apparently develop "thermal leaks" through the metal itself, not at the solder joints. These traps were replaced by stainless steel and no further difficulty was encountered.

In order to be able to vacuum-check the system for pressures lower than the vapor pressure of mercury it was necessary to by-pass the Hg diffusion pumps. Under these conditions pressures on the order of 5 to 10 microns could be realized without recourse to the cold traps. Initially, ten oil changes and 4 days' running were required to attain such a low pressure; however, a few hours now suffice.

A number of things must yet to be done before the system will be ready for He³:

1. Connect Hg diffusion pump water-cooling lines and test pumps.
2. Fabricate heaters for the two charcoal traps.
3. Check for intervalve leaks.
4. Gather data on pumping speeds for both the roughing system and the circulating diffusion pump.
5. He⁴ dry runs.
6. Convert leak detector to detect He³ and increase its sensitivity.
7. Fabricate a He³ "standard leak" for calibration purposes.
8. Withdraw a small sample of known volume for He³ storage tank prior to run and analyze it on the mass spectrometer for percent of He³ content and impurities.

Moyer

REPORT ON NOBLE GAS SCINTILLATION

Scintillations from argon in the gaseous state have been observed for pressures from 5 psi to 140 psi. Preliminary data indicate agreement with previous work.* The following were investigated, with both 5.15-Mev alphas from Pu^{239} and 5.3-Mev alphas from Po^{210} :

1. Pulse height as a function of pressure.
2. Pulse height as a function of temperature.
3. Pulse height as a function of time (to study any poisoning effects).

Pulse height decreases slightly (a few percent) with pressures above 30 psi. There is not sufficient argon below 10 psi to completely stop the alphas, and pulse height drops rapidly. Pulse height from the Po^{210} alphas was above that of the Pu^{239} alphas. However, the energies are too close to give any helpful information on possible scintillator linearity, zero-energy intercept, etc.

An increase in pulse height of about 45% was noted, with a corresponding temperature decrease from 20°C to -100°C . Poisoning data are not complete at this time.

Work on argon in the liquid phase will begin in the near future. Pulse height will be explored as a function of liquid depth, pressure, and time. Gamma sources, which produced essentially no scintillations from the gaseous state, will be investigated. A Sr^{90} source, with an associated β^{-} , will be used.

* Nobles and Northrop, Nucleonics 14, 5 April 1956;
Eggler and Huddleston, Nucleonics 14, 5 April 1956.