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# PROGRESS REPORT No. 77

August 15 to September 15, 1949

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UNIVERSITY OF CALIFORNIA, RADIATION LABORATORY

August 15 to September 15, 1949

PROGRESS REPORT No. 77

## 1. Bevatron

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Quarter Scale Model. Frequency tracking has been improved by providing separate adjustments to correct the frequency magnet current relation at eleven points at fixed frequency intervals as well as up to ten points at adjustable intervals. No appreciable improvement was found when using more than six connections at adjustable intervals.

The decrease in beam is now almost entirely explained by gas scattering. An inflector with a tip one inch high and with a one-half inch gap has been installed and gave an increase in beam. The beam leaving the injector channel is $10^{-8}$ coulombs per pulse and $10^{-10}$ coulombs is accelerated to .6 Mev with the aperture 9 x 27 inches. Reduction of the aperture to 6 x 18 inches reduces the beam by about a factor of six.

Installation of the fractionating pump jets has been completed and the system was pumped down again. It is too soon to look for any improvement in the tank vacuum as adjustments in the pump are still being made. Some time has been spent in de-bugging the frequency control system designed by Baker which has been installed so that it can be connected in place of the original control. Other experiments were made to verify previous results. The operating time has been reduced from 15 to 10 hours per day.

Full Scale Bevatron. The building contractor started work on September 1. It is estimated that the building should be completed by June 1, 1950. The first concrete was poured for the building foundations on September 16. One magnet yoke slab has been assembled but several short circuits were found between plates so that more thorough removal of burrs will be required. The magnet leg slab assembly fixture has been delivered to the shop but the sample leg plates have not yet been delivered due to machining difficulties. Design studies of the vacuum system are being made. It appears possible to locate the diffusion pumps below rather than to one side of the tangent tanks, thus providing access to both sides of the beam for the full length of the tank at each tangent section. It has been decided to provide water cooling for the magnet yoke to keep the temperature of the internal pole tips to what is believed to be a sufficiently low value. This cooling will be accomplished by means of copper sheets clamped between pairs of yoke plates and soldered to copper water tubes running in a radial direction along the top and bottom of the magnet frame. Four tubes will be used for each 2-1/2 degree sector.

## 2. 184-inch Cyclotron Operation

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The cyclotron was used for research experiments approximately ninety-two percent of the 546 hours that the crew was on duty.

New equipment to be installed next month is being prepared and progress is satisfactory. This equipment involves primarily a new larger probe lock and an improved electrostatic deflector mechanism.

## 3. 60-inch Cyclotron

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Final assembly is pending the delivery of the new dees from the fabrication shop. It is expected that the instrument will be ready for beam search within approximately three weeks.

## 4. Synchroton Operation

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The erratic performance and low beam intensity mentioned in last month's report were found to be caused by charging up phenomena inside the donut. The donut surface was re-sprayed with conducting paint, and the beam intensity has become very constant with none of the variations in intensity from pulse to pulse that were formerly noted. It is now possible to run with an intensity well over 2000 R/hour for long periods of time.

Tests are in progress to determine the design of peaking strips which can be located near each of the octant coils in an attempt to determine an absolute setting of the octant resistances which will give reproducible performance. These tests to date indicate the necessity of heat treating the peaking strip core material in a reducing atmosphere in order to obtain uniformly sharp signals.

During the past month, runs have been made for the meson program, using the variable thickness copper absorber. Blank runs have also been made with the equipment to be used as a liquid hydrogen target.

The research program on Compton scattering has been completed for the present. Additional work on this problem may be done next summer if Professor Hofstadter can return to Berkeley.

Runs have continued on the program of measuring transition thicknesses for different materials. It has been found that the ionization chamber is not yet large enough to indicate all the scattered radiation, and additional equipment must be built to reduce this error.

Work has continued on the excitation of activities in various materials by means of the synchrotron x-ray beam.

## 5. Linear Accelerator and Van de Graaff

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The last month has been devoted almost entirely to research about the linear accelerator rather than in experiments with it. After talking for a year about trying the accelerator without grids, the grids were finally removed a few

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weeks ago. The machine ran in some ways better than before. The x-ray background was reduced by a large factor; most of the x-rays apparently arose from field emission electrons, which came from the grids where the electric field was concentrated. The beam was foussed about as well as before, and it had a strong component at 32 Mev. The beam was down in current by a factor of about five, but it was not possible during the test, to monitor the injected current. A new magnet to deflect the 4 Mev protons has now been installed, and the efficiency of the gridless accelerator will soon be checked. It would be an understatement to say that the reason the accelerator operates without grids is not understood.

A number of changes in the accelerator are being made at the present time. Carbon sleeves are being placed in the drift tube holes to cut down the neutron background. A refrigerated baffle has been installed in the Van de Graaff high voltage terminal to eliminate oil vapor from the column.

## 6. Experimental Physics

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Film Program, $\pi$- and $\mu$-Meson Masses. Apparatus is being designed for a measurement of $\pi$ and $\mu$ meson masses by the proton comparison method. In this method the meson masses are not calculated in absolute terms as in the method used earlier but are found by measuring the ratios of meson masses to the proton mass. The results do not depend on a knowledge of the absolute magnetic field, but do involve measurements of relative magnetic field values. If the proton and meson velocities are approximately equal, the values of the meson masses obtained are not affected much by errors in the range-energy relation.

The objective of the new measurement is to find $\pi$ and $\mu$ meson masses which will have probable errors as low as one percent. Previous measurements have had probable errors of three or four percent. Values published in the program of the Berkeley meeting of the American Physical Society[1] were $m_\pi = 285\ m_e$; $m_\mu = 216\ m_e$, where $m_e$ is the mass of the electron. These masses were measured by a method in which the mass values depend strongly on the range-energy relation. The recent redetermination[2] of this relation gives a different result from that used previously. If the mass values reported in the Berkeley meeting are corrected for the recent changes in the range-energy relation, the masses are: $m_\pi = 278\ m_e$, $m_\mu = 210\ m_e$.

Cross Sections for $\pi$ Meson Production by 345 Mev Protons. Measurements are continuing on the $\pi$ meson production cross sections by 345 Mev protons at $90^\circ$ to the proton beam. The energy distribution of mesons from carbon at this angle has a soft peak around 50 Mev and extends to about 120 Mev. The cross section at the peak is about $2 \times 10^{-30}$ cms.$^2$ per Mev steradian nucleus. A similar experiment for lead gives a peak around the same place but the drop-off in the distribution seems to come somewhat earlier. The cross section for lead is about ten times the carbon cross section at this angle. The number of $\pi$ mesons on which these results are based is nominal and scanning of plates is continuing so that these results may be made more precise.

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[1] A. S. Bishop, Phys. Rev. 75, 1468 (1949)
[2] H. Bradner, W. H. Barkas, F. M. Smith, A. S. Bishop, to be published.

Cloud Chamber. The cloud chamber group has been making the measuresments on the x-ray spectrum from the synchrotron. In addition a cloud chamber is being prepared to do the n-d scattering experiment.

Cerenkov Radiation. This experiment was essentially stationary during the month waiting for samples of high refractive index glass to arrive. As such glass is of unusual composition the manufacturer has had difficulty in producing blanks of optical quality. Another experimental glass was obtained which has advantages over that previously used, but it is not yet obtainable commercially.

Measurement of Total Cross Sections of Nuclei for 40 Mev Neutrons. During this month the following powdered and granular substances have been investigated: $CaCO_3$, $SrCO_3$, $BaCO_3$, B, S, Melamine, $MnO_2$, LiF. The powders were packed into 1-1/2 inch O.D. x .035 inch wall brass tubes with 1/16 inch aluminum end flanges. The lengths of these tubes varied from 8 inch to 12 inch according to the expected attenuation. The results were, on the whole, consistent with cross sections determined with solid and liquid attenuators. In addition to the above mentioned powders several heavy metals were repeated.

The present status of the experiment may be summarized as follows: Cross sections of 33 nuclei have been measured. This has involved measurements using 36 different absorbers of which 18 are tentatively completed. We intend to investigate about 11 more substances including 5 gases.

High Energy Photons. The high energy photon group has been engaged principally in refining cross section measurements and laying the groundwork for future experiments.

Relative and absolute cross sections have been measured by comparing gamma yields from carbon with the yield of $C^{11}$ in the same target. Experiments of this type indicate that the photons are emitted practically spherically symmetrically in the C. M. system, and give a total cross section of $1 \times 10^{-27} cm^2$ in the case of 340 Mev protons on carbon.

The possibility of finding photon-photon coincidences by means of counter techniques, in conjunction with the new nuclear scattering technique for obtaining a deflected beam, is being explored.

Also in progress is the design of system using Panofsky's Hydrogen Bomb for investigating photon production in the case of proton-hydrogen collisions.

Proton-Proton Scattering at 340 Mev. A considerable electronic re-building program is underway to allow the use of fast scintillation counters. A distributed amplifier has been developed which has adequate speed and a symmetrical distributed coincidence circuit has been developed. The photomultiplier tube in conjunction with its crystal must still be tested. It is still necessary to find a satisfactory means of feeding the signal into a low-impedance cable.

$Li^8$ Production Cross Sections. The measurements of $Li^8$ production cross sections are being evaluated.

Po Excitation Functions. Measurements of excitation functions for the production of $Po^{206}$, $Po^{207}$ and $Po^{208}$ are continuing.

Fission Excitation Functions. A final report, UCRL-436, on the work on fission excitation functions has been written.

## 7. Theoretical Physics

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Mesons. Calculations of the energy and angular dependence of mesons produced by protons have been made for two nuclear models. The model worked out by Chew for carbon leads to results for the energy spectrum at 90° and for the absolute cross section which agrees very well with the observations of Richman and Wilcox on carbon. Taylor's calculation assuming a degenerate Fermi gas in the nucleus gives less high energy tail, a change which seems to be borne out by the experimental results on Pb. It appears that different meson theories give different $\pi^+/\pi^-$ ratios, and calculations on this are in progress. The predicted neutral meson distribution also agrees very well with that deduced from the observed photon distribution.

The ratio $\pi^+/\pi^-$ for x-ray produced mesons seems to be accounted for reasonably well in terms of the currents carried by meson and proton. More accurate experimental results are needed to check the theory in detail. Any divergence would then be evidence for magnetic moment effects. The total cross section for x-ray production of mesons agrees with the observations, but there is some question concerning the detailed spectrum and angular dependence (which is sensitive to the kind of meson theory).

Scattering. The p-p results at 30 Mev can be accounted for if tensor forces are supposed to act as well as central forces (this implies a lack of charge independence of nuclear forces). However, the predicted 340 Mev scattering cross section is only 1/3 as large as that observed. This is particularly strange since no such discrepancy showed up in the 280 Mev n-p scattering.

It is hoped that the n-d calculations are now in good order.

Shower Theory. The shower theory is being compared with the observations on total ionization and on $\gamma$-n and similar reactions. Preliminary results are quite encouraging and it seems likely that it will be possible to fit the results in detail. For example, it has been found that the x-ray energy one must assume effective in the $\gamma$-n reaction on Cu is 19 Mev, while for C one obtains 29 Mev. Both are very reasonable values.

## 8. Chemistry

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Plutonium Isotopes Produced with Prolonged Neutron Irradiation. A sample of plutonium which had been irradiated in a Hanford pile for approximately three years was recently purified, and a preliminary examination was made of the isotopic composition. Examination with the mass spectrograph showed for the first time a small amount of $Pu^{242}$ produced by a third order neutron capture process starting with $Pu^{239}$. The composition of the sample was as follows:

| | |
|---|---|
| $Pu^{239}$ | 58.5 percent |
| $Pu^{240}$ | 35.0 percent |
| $Pu^{241}$ | 5.0 percent |
| $Pu^{242}$ | 1.5 percent |

These measurements along with some others should allow one to calculate the neutron capture cross sections and disappearance cross sections for these successive nuclei.

A new technique was used to determine the half-life of $Pu^{240}$. Some of the plutonium in the mass spectrograph was caught on a platinum foil, and this was placed in contact with an Eastman NTA photographic plate. By counting the alpha tracks in the emulsion at the two positions of mass 239 and 240 one can determine the half-life of $Pu^{240}$ relative to that of $Pu^{239}$ if the relative abundance of atoms is also known. These measurements should be capable of great accuracy but until the slit definition is improved and a large number of tracks have been counted, an accurate value cannot be reported. There were an insufficient number of tracks at mass 242 to make any meaningful estimate of its half-life, and this is in agreement with the predicted long half-life for $Pu^{242}$.

Barium Isotopes from High Energy Fission of Uranium. In the fission of bismuth with 200 Mev deuterons it was found that only $Ba^{133m}$ appeared in appreciable yield in the barium fraction. It has recently been found in the case of the fission of uranium with 350 Mev protons that a wide range of mass numbers of barium isotopes are present, including those on the neutron deficient side of stability as well as those with neutron excess. The mixture was run through the mass spectrograph, and the transfer technique showed four activities with half-lives longer than several hours. These are $Ba^{131}$, $Ba^{133m}$, $Ba^{135m}$, $Ba^{140}$. The disappearance of the $Ba^{135m}$ line at about the same time that the $Ba^{133m}$ line had decayed indicates that 135 is probably the mass number assignment for the 29-hour barium previously known to be an excited state of one of the stable barium isotopes.

Alpha-Emitters in the Rare Earth Region. A new group of alpha-emitters has been produced in the middle region of the rare earths on the neutron deficient side of stability. No isotopic assignments have been made, but some chemical separations as well as indications from the targets irradiated show that these nuclei probably lie from europium (element 63) to holmium (element 67). In the terbium fraction from the irradiation of dysprosium with 200 Mev protons were found a 4-hour period with 4.0 Mev alpha-particle energy and a 17-hour period of 3.65 Mev. Unidentified activities are a 7-minute period of 4.2 Mev, a 20-minute period of 4.1 Mev, and a period of approximately 6 weeks half-life with a 3.1 Mev alpha particle. Some of these same activities have also been produced by the irradiation of gadolinium.

These alpha activities differ in kind from those previously reported in gold and mercury in that they are relatively close to beta stability and have moderately high alpha branching. An attractive hypothesis to explain this band of alpha-emitters is that they decay into nuclides in the stable region around 82 neutrons and are thus analogous to the energetic alpha-emitters of polonium, astatine, emanation, etc. which decay into the comparable region of stability at 126 neutrons.

Ground State Transition for $U^{235}$. It has been known for some time that $U^{235}$ has associated with it a gamma ray of 160 Kev in high abundance. The supposition is that the observed alpha-group cascades through this gamma ray and that the alpha group corresponding to the ground state transition is not observed. Recently a sample of highly separated $U^{235}$ has been obtained in which the $U^{234}$ alpha particles were actively fewer in number that those of $U^{235}$. This made is possible to search

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for the missing ground state group of $U^{235}$ as it might not be covered up in this case by the $U^{234}$ alpha particles present in natural uranium in preponderant abundance. A sample of this separated material was measured in the alpha-particle pulse analyzer, and an alpha particle group was readily discernable at an energy approximately 160 Kev higher than the main $U^{235}$ group. With the assumption that these alpha particles are the missing group from $U^{235}$ the abundance was calculated as 10 $\pm$ 1 percent.

Vapor Phase Hydrolysis of $LaCl_3$. Little is known about the conditions of hydrolysis of the halides of the lanthanide and actinide elements even though this is a common reaction which takes place when one attempts to prepare the pure trihalides. This hydrolysis which produces the oxyhalide is a constant source of difficulty in preparations which are used for reduction to the metal. The reaction type is the following.

$$RCl_3 + H_2O = ROCl + 2HCl$$

A method has been devised for determining the equilibrium constant and free energy of the reaction which is much less laborous than previous methods which demanded large numbers of analyses of the reaction mixture at different HCl and $H_2O$ partial pressures. This method consists of placing a sample of lanthanum oxide on a pan attached to the beam of a quartz cantilever balance, with the whole assembly in a quartz tube through which is flowed the gas mixture. In the case of lanthanum there is approximately 20 percent weight change from $LaCl_3$ to LaOCl, and it is readily seen by deflection of the beam in which direction a particular gas mixture shifts the equilibrium. The equilibrium constant and free energy of the vapor phase hydrolysis of $LaCl_3$ was determined at a series of temperatures, and results are indicated below:

| $T_{^oK}$ | K | $\triangle F$(Kcal) |
|---|---|---|
| 814 | 2.94 | -1.74 |
| 775 | 1.14 | -0.20 |
| 739 | 0.47 | 1.11 |
| 701 | 0.136 | 2.78 |
| 665 | 0.036 | 4.39 |
| 625 | 0.008 | 6.0 |

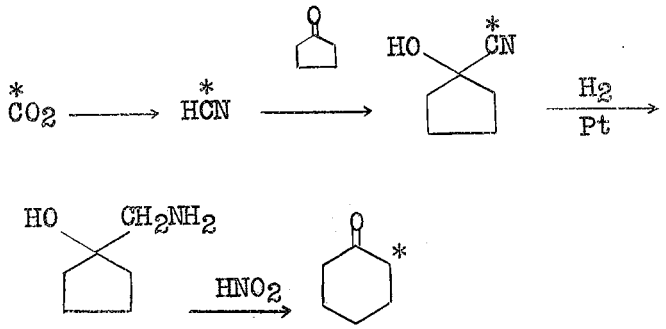


Part B

Synthetic and Experimental Chemistry. The study of the synthesis of the following compounds labeled with $C^{14}$ has continued: isopropyl bromide-methyl-$C^{14}$,

isobutyl bromide-1-$C^{14}$, valine-methyl-$C^{14}$, valine-2-$C^{14}$, valine-1-$C^{14}$, leucine-1-$C^{14}$, leucine-2-$C^{14}$, 1-bromo-4-methyl-butane-1-$C^{14}$, sodium isobutyrate-1-$C^{14}$, sodium isovalerate-1-$C^{14}$, sodium isocaproate-1-$C^{14}$, cyclohexanone-2-$C^{14}$, succinic-methylene-$C^{14}$ acid, malic-methylene-$C^{14}$ acid, fumaric-methylene-$C^{14}$ acid, ethyl oxalacetate-methyl-$C^{14}$, zinc lactate-2-$C^{14}$ and zinc lactate-3-$C^{14}$.

A preliminary phase of the tiffeneau ring expansion study has been completed:




That the mechanism actually goes as postulated has been verified. At present, work is underway to simplify the chemical procedure and increase the yields.

The preparation of carboxyl-labeled naphthylmalonic acid for use in an isotope effect study (a decarboxylation reaction) has continued with fair progress. α-Naphthyl glycolic acid has been prepared and the conversion of this to the chloro acid has been achieved by several methods.

The preparation of demerol with $C^{14}$-labeled formaldehyde and inactive formic acid has been described in a previous report. The role of the two reagents, formaldehyde and formic acid, in this reaction has not been clearly understood. It has been found that when the alkylation was carried out using labeled formaldehyde and inactive formic acid, only the demerol formed and the recovered formaldehyde was radioactive while the carbon dioxide given off in this reaction was inactive. When labeled formic acid and inactive formaldehyde was used in the reduction, neither the resulting demerol nor the unreacted formaldehyde was radioactive, but the carbon dioxide had the same specific activity as the starting formic acid.

Biological Industry. Purines and Nucleic Acids. Recent work has indicated that differences exist between normal and cancerous cells in the manner in which they metabolize certain purines. Other workers have also reported differences in nucleic acids in normal and tumor-bearing animals. As an aid in the study of this and other problems of purine metabolism and as an opportunity for treatment of cancer in the use of synthetic nucleotides, we have undertaken the synthesis of a number of labeled naturally occurring purines, purine derivatives and isoteres among which are adenine, guanine, thiazolidino-purine, 8-mercaptopurine and 7-thioxanthine.

Metabolism of Propionic Acid-$C^{14}$. An investigation of the metabolites resulting from incubation of mouse liver slices with carboxyl-labeled sodium propionate is being continued by the use of paper chromatography. Alanine has been identified as one of the more important amino acids produced in these incubation experiments. In the hopes of establishing the mechanism by which this compound is formed, the components of the ether-soluble fractions are being studied and degradations experiments will be carried out on the alanine.

Immunochemistry. The experiments to produce tagged antibodies in rabbits have been unsuccessful using glycine-2-$C^{14}$ as a source of labeled carbon. Although the antibodies were formed, the amount of labeled glycine taken up was insufficient to give accurate results. It is hoped that this work can be repeated later with another amino acid, probably leucine, to obtain more accurate data.

An attempt has been made to isolate the Rh antigen from the amniotic fluid of mothers who had given birth to Rh positive babies. At present, the titer per unit weight is being determined and an attempt made to concentrate the antigen.

Metabolism in Mice of $C^{14}$-Labeled Compounds. The studies in the rate of elimination of $C^{14}$ fed to mice in the form of simple organic compounds or amino acids has continued. Among others, the following labeled compounds have been investigated: sodium acetate-1-$C^{14}$, sodium acetate-2-$C^{14}$, methionine-methyl-$C^{14}$, sodium butyrate-4-$C^{14}$, urea-$C^{14}$ and glucose-1-$C^{14}$.

Photosynthesis Chemistry. The study of the mechanism and kinetics of photosynthesis by green plants has continued. As primary tools labeled carbon, hydrogen and oxygen have extended research in the studies of the path of carbon in photosynthesis. Thus, by using labeled carbon dioxide it has been possible to study the path of carbon from the atmosphere to the constituents of cellular material; with labeled hydrogen it is hoped to investigate the formation of reducing agents during photoreduction and with $O^{18}$ it may be possible to determine the path from water to oxygen gas.

Degradation of Intermediates. In order to determine the path of carbon in photosynthesis known intermediates and related compounds in sugar synthesis are being degraded and the positions of the labeled carbon atoms in each compound determined as a function of time of photosynthesis in $C^{14}O_2$. Among the compounds currently being degraded are phosphoglyceric acid and alanine. It appears that phosphoglyceric acid is the major product in photosynthesis formed in thirty seconds. Some evidence now exists for the formation of a precursor of phosphoglycerate which may be phospho-enol-pyruvate. It is possible that phospho-enol-oxalacetate may also be formed.

Feeding Experiments with Labeled Intermediates. The fate of several labeled compounds related to photosynthetic intermediates has been investigated in a preliminary experiment. Labeled acetates, formate, alanines and glycines have been fed to the algae Scenedesmus in both light and dark. The radioactive products formed have been separated and identified. By the use of these compounds it is hoped to further elucidate the metabolic pathways involved in plant metabolism. The major product from feeding either of the glycines is serine. After feeding alanine, considerable activity has been found in glutamic acid and the proteins and fats. With methyl-labeled acetate most of the activity is found in the various plant acids and glutamine.

Photosynthesis and Respiration. Work described earlier has been continued to determine the relationship between the photosynthetic path of carbon and normal respiration processes. In these experiments labeled intermediates are formed during short photosynthetic periods with $C^{14}O_2$. The light is then turned off and respiration allowed to proceed for a determined time before the plant is

rapidly killed. The products formed are then determined by the use of a radioautograph of a filter paper chromatogram. Degradation studies now underway should lead to a detailed exposition of the sequence of compounds involved.

The Path of Oxygen in Photosynthesis. Since the work of S. Ruben et. al. in 1941 no information has been obtained regarding the source of the oxygen evolved during photosynthesis. Calvin and Karrer have independently suggested that the oxygenated carotenoid pigments might be such intermediates. Carotenoids are invariably associated with chlorophyll in green plants. Karrer has isolated a number of epoxide structure among oxygenated carotenoids which conceivably could be involved in the oxidation of water. A straightforward way of testing such a hypothesis would be to photosynthesize a plant of high carotenoid content with water containing Oxygen 18, isolate and purify the various epoxide and furan carotenoid pigments and determine whether or not these pigments contain a higher percentage of $O^{18}$ than an identical sample kept in the dark. Such an experiment has been carried out; the details of the experiment will be reported as soon as the mass spectrographic analysis of the sample is available.

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## Chemistry

### Part C. Project 48B

Metals and High Temperature Thermodynamics. Work is in progress on the following problems:

1. Studies of refractory carbides, borides, and silicides.
2. Thermodynamics of CN and $N_2$
3. Absorption coefficients of CN and $C_2$.
4. Thermodynamics of molybdenum halides and oxides.
5. Thermodynamics of gaseous aluminum and iron oxides and hydroxides.
6. Low melting metal systems.
7. Theory of bonding in solid and gaseous oxides.
8. Construction of high temperature calorimeter and theory of its use.
9. Apparatus for the measurement of thermal conductivities of gases.
10. Design of equipment to extend work on film boiling to the case of forced convection.

Basic Chemistry. Solvent Extraction. The following problems are under investigation:

1. The exchange of iodine atoms between iodate ion and iodine.
2. The chelate complex of lanthanum with TTA.
3. Thermodynamic studies on rhenium.

Engineering Development of Plutonium Separation. The following subject is being investigated:

1. Solvent extraction using chelate process.

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Ore Reduction. The following subjects are under investigation:

1. Study of oxidation state of uranium with polarographic methods discontinued because of general shift of emphasis in the section. Micro amperometric titration of uranyl ion with chromous ion under investigation.
2. Solvent extraction using chelate process.
3. The construction of a photomultiplier has been completed and is now being used in fluorimetric determination of micro amounts of uranium. A Photovolt Model 512 Fluorimeter is being used for uranium analysis in conjunction with the solvent extraction using chelate process.

## 9. Medical Physics

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### Part A

Tracer Studies. Tracer studies are being continued using $Rh^{105}$, $Sm^{153}$, and $Se^{175}$. The fate of $Cb^{95}$ in normal and tumorous animals is being studied after complexing with a variety of compounds of biological origin.

Decontamination and Bone Metabolism Studies. Decontamination. Since massive doses of parathormone cause active resorption of bone, the effect of such treatment for plutonium decontamination was studied in conjunction with therapy with massive doses of zirconium citrate. Young rats were injected intravenously with 10 micrograms of Pu(VI). Massive doses of parathormone (E.Lilly) - 5 units per gram - administered immediately following the plutonium injection, and for the succeeding 6 days had no significant effect on the excretion of plutonium or on the distribution in the body. Administration of single massive injections of zirconium citrate (20 mg. Zr) doubled the urinary excretion of Pu (from 12 percent to 25 percent), increased the amount in the liver, and caused a corresponding decrease in the amount retained in the carcass and skeleton. Massive doses of parathormone did not significantly enhance this effect of zirconium citrate.

Time studies were made of blood levels, tissue deposition and urinary excretion of $Y^{90}$, $Cb^{95}$ and $Pu^{239}$ in normal adult rats, and in similar animals treated with large doses of zirconium citrate (40 mg. Zr, IP). Preliminary analyses indicate a positive effect in the case of zirconium citrate as early as 10 minutes after injection in the case of all three elements, with significant increases in urinary excretion.

Bone Metabolism. Because of the interest in bone osteoid matrix as the site of deposition of many fission products and other heavy metals, attempts are being made to increase the osteoid matrix production in rachitic rats by improvements in diet. The protein and vitamin content of the low phosphorus diet has been increased to encourage growth and improve the general condition of the experimental animals. Early growth curves indicate benefit from these changes.

Radioautographic Studies. Work has continued on the project for comparison of the differences in localization of calcium, strontium, promethium (element 61)

and plutonium at the costrochondral junction of 150 gm. rats, 1 and 24 hours after injection. Americium is being added to this list. The calcium and promethium radioautographs have been completed. Amongst the various sites of deposition of this element, the deep (osteogenic) layer of periosteum can almost certainly now be included, on the basis of a unique anatomical situation at the costochondral junction, namely, the presence of prolongation of such tissue for a short region independent of adjacent bone. The strontium series is being repeated in higher dose at the one-hour interval since although uptake of the element is demonstrable at the dose used (10 micro-curies) the activity within the sections is so slight as to require unreasonably long exposure times. Preliminary examinations of the plutonium radioautographs suggest that the earlier observations will be confirmed that this element shows no appreciable localization in the chondral segment of the rib, even near the calcified cartilage core, by ordinary radioautographic techniques.

A simplified routine has been developed for the project on uptake of alkaline earth metals in the osteoid of rachitic rats. By means of survey radioautographs the epiphyses of large numbers of animals may be examined and selection may thus be made, including only those which the survey shows to be markedly rachitic, for critical study by the longer and more arduous techniques for radioautography of sections.

Radiochemical Isolation. Three one-millicurie batches of $Rh^{105}$ have been separated from neutron irradiated $RuO_2$ using $H_2SO_4$ - $NaBrO_3$ distillation method previously reported. Half-life and mass absorption measurements show a long-lived contaminant, presumably produced from impurities in the bombardment. This activity has not been identified.

The recovery of neptunium from animal ash has continued using a method reported previously. Four 15 millicurie Oak Ridge shipments of $Sm^{153}$ were complexed for injection in sodium citrate at pH 7.

Several papers on the isolation of carrier-free isotopes have been completed and submitted for publication. A manual on the preparation and isolation of carrier-free radioisotopes is being prepared.

## Medical Physics

UNCLASSIFIED

### Part B

Nucleoprotein Metabolism. The Effect of Neoplastic Tissue on the Turnover of Desoxypentose Nucleic Acid. In the course of a general investigation of desoxypentose nucleic acid turnover rates a striking difference was found between the tissues of normal mice and those bearing transplants of mammary carcinoma.

The general plan of these experiments is similar to that used by Hevesy[1]. The relative nucleic acid turnover rate was measured by giving a tracer dose of radioactive sodium phosphate, sacrificing the animals after two hours, and isolating the desoxypentose nucleic acid from the tissues to be investigated. The animals used were female A-strain mice bearing bilateral transplants of a mammary carcinoma

[1]Hevesy, G.; Nucleic Acid Metabolism, Advances in Biological and Medical Physics, 1, 409, 1948.

induced in the Strong A-strain of mice[2].

From the table below it is evident that there is a very significant increase in the specific activity of the nucleic acid in the livers, spleens, and kidneys of tumor bearing animals. The increase is proportional to the tumor size, but is not linear. In the case of the small intestines there is a significant lowering of the specific activity of the host animals. Histological examination of the tissues showed no metastases.

Sodium phosphate was given intra-peritoneally. The mice were sacrificed two hours later and the tissues were dissected out as rapidly as possible and the isolation of the nucleic acid was begun. In order to obtain enough purified desoxypentose nucleic acid the tissues from three animals had to be pooled.

The method used for the isolation of the desoxypentose nucleic acid was essentially Levene's as modified by Klein and Beck[2]. Some changes were necessary in order to make the method suitable for a tracer experiment.

Klein and Beck found that the nucleic acid was pure by chemical criteria after only three repurifications. However, as can be seen from the values given below, eight to ten precipitations were found necessary in this experiment in order that the specific activity of the nucleic acid remain constant upon successive re-precipitation. In a typical liver sample the following values were obtained on aliquots taken after the stated number of precipitations.

| Number of Precipitations | Specific Activity |
|---|---|
| 3 | $27.1 \times 10^{-4}$ |
| 6 | $4.9 \times 10^{-4}$ |
| 8 | $3.7 \times 10^{-4}$ |
| 10 | $3.9 \times 10^{-4}$ |

Individual specific activities of tissues measured in this manner after 10 precipitations show great reproducibility. Partial purification of desoxypentose nucleic acid must include a variable amount of some high specific activity phosphate contaminant, which accounts for the variability of several orders of mangitude of Hevesy's studies and earlier studies in this laboratory patterned after his procedures.

The presence of mammary carcinoma transplants significantly alters the turnover of desoxypentose nucleic acid in mice. It is suggestive that this may be an indication of the action of a "growth stimulating" factor in the presence of this tumor. Work is in progress on other tumor types and other strains of mice and rats.

Physical Chemistry. Infra Red Spectroscopy. Applications of infrared spectroscopy to medical research problems are being explored. It is hoped that structural correlations can be established in the physiologically important classes of large molecules, including steroids, proteins, nucleic acids, and porphyrins. In

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[2] Klein, D., and Beck, Z.; Chemische Zusammemsetzung Von Mukleinsaure in Malignen Geweben, Z. f. Krebsforschung, 42, 163, 1935.

addition to fundamental studies of molecular structure, the possibilities for specific analyses and identifications of such substances in tissues will be investigated.

The spectra of some pure proteins have been run, and the differences that exist in them appear to be potentially useful for classification purposes. Further work on a larger variety of proteins will be required to establish a significant correlation, however.

Samples of pure steroids are being collected from various sources and work on this class of molecules is awaiting their arrival.

Arteriosclerosis Problem. a. Cholesterol Metabolism. The metabolism of cholesterol in its relationship to the formation of the atherosclerotic plaque is being investigated with the use of tritium as a label for the molecule. As yet no one has synthesized radio-cholesterol with either $C^{14}$ or $H^3$ incorporated into definite specific sites on the cholesterol molecule. However, for this particular problem the interest is at first in the handling and deposition of the molecule as a whole rather than any of its metebolites. For this reason even random labeling of hydrogens of the cholesterol molecule with $H^3$ should give quite valuable information. During the past month work has been in progress on the adaptation of an in vitro technique for incorporation of $H^3$ into cholesterol following the literature data on similar incorporation of D into cholesterol by exchange. The catalysts (Bakers platinum oxide) have been obtained and preliminary runs made. The details of isolation of the $H^3$ labeled cholesterol from the reaction mixture and proof that the product obtained is cholesterol are now being studied. As soon as this is completed, it will be possible, we have calculated, using the quantity of tritium that has now arrived from Argonne Laboratory, to attempt an answer to the vexed problem of deposition of exogenous cholesterol in arteriosclerotic lesions. Though by inference it has been taken that in rabbits being fed cholesterol, the fed cholesterol deposits in the lesion, this has never been demonstrated as a fact. In view of its importance with reference to the question of exogenous cholesterol intake in humans, an effort to obtain the answer in the rabbit and possibly the chicken seems highly worthwhile. The actual feeding experiment will start as soon as the preparation of labeled cholesterol has been completed.

Meanwhile the techniques for handling samples and purifying cholesterol as being worked out for another approach to the cholesterol problem, namely, a determination of the extent of incorporation of endogenously synthesized cholesterol in atheromatous plaques and the extent of turnover of cholesterol in such plaques. It is expected, from calculation, that by maintaining rabbits on subcutaneous injections of $H^3$ labeled water, that one should be able to measure the rate and extent of incorporation of endogenously synthesized cholesterol into arterial wall cholesterol. The animal experiments on this are just starting now since an adequate quantity of tritium has arrived. Since for this problem a highly pure cholesterol must be isolated from arterial tissue in order to assure that $H^3$ activity is truly in cholesterol, much effect is now being put into the isolation and purification of cholesterol from this tissue.

b. Ultracentrifugal Studies of Serum in Rabbits Developing Atherosclerosis. As reported in UCRL-430 a study is in progress on the nature of the serum lipids and lipoproteins which appear in serum of rabbits as they are fed cholesterol and as they develop arteriosclerosis. Previous workers have merely measured alterations in blood cholesterol level, without reference to the nature of the large molecule complexes (some containing protein) in which the cholesterol and other lipids actually circulate in blood. In view of the high likelihood that the metabolic defect which results in the formation of atherosclerotic plaques may be related to the form in which the lipids are carried, such studies seem pertinent. Further, when studies on radiocholesterol turnover and deposition are being made it will be imperative to know which fraction's turnover and deposition is actually being studied.

In the previously reported work it was mentioned that new components appear to develop progressively as the animals being more and more hypercholesterolemic. This has been substantiated and extended in the past month. The components do not represent a continuum of materials, but rather specific, reasonably well defined groups. It appears that all the rabbits start by developing a large increase in a component containing cholesterol which we are calling a $B_2$ - low density lipoprotein. Then as feeding cholesterol continues, a series of cholesterol containing lower density lipids (or lipoproteins) appear in a regular succession. These molecules have different sedimentation constants from the $B_1$ lipoprotein and it appears are molecules of much higher molecular weight. The present animals are to be sacrificed in the next week or two, and a preliminary correlation of the ultracentrifugal components with the extent and severity of the arteriosclerotic lesions will be attempted.

Meanwhile the construction of a light scattering photometer for the study of molecular weights and structure of such large lipid and lipoprotein molecules has progressed further, and it should be possible soon to start using this instrument for further characterization of the components of serum which develops as arteriosclerosis is produced.

Radiation Effects on Microorganisms and Studies on the Nature of Radiosensitivity and Radioresistance. Determinations of radiosensitivity and variations therein with age of culture, condition of exposure of organisms to radiation, and other variables continue. The phenomenon of recovery from radiation effects are being studied.

Cobalt Polycythemia. Previous work in this laboratory has indicated that the production of polycythemia in rats by cobalt can be inhibited by administering cobalt as the cobalt-cysteine and cobalt-histidine complexes. Using $Co^{60}$ as a label it has been shown that the amino acid depresses the accumulation of cobalt in the bone marrow, the tissue of which is highly likely to be primarily involved in the production of polycythemia. It is now of interest to know by increasing the dose of complex administered to a point where the bone marrow cobalt level approaches that in animals given cobalt alone whether polycythemia will develop, or whether the amino acid has truly deflected cobalt metabolism into a pathway whereby the hematopoietic activity is not manifested. These studies are now underway.

## 10. Health Physics and Chemistry

Radiation Survey Studies. The neutron field intensity in the Linear Accelerator area has been studied from the standpoint of intensity and origin.

It was determined that a considerable contribution to the neutron field was arising from protons striking drift tubes near the exit end of the accelerator. The total field intensity of fast neutrons in certain inhabited regions, and in other frequently inhabited regions, was of the order of twice what should be allowed for continuous operation.

Revisions of grid systems and orifices in the drift tubes are in progress, in an effort to eliminate the spurious source of neutrons and also reduce the x-ray background.

Other Studies. The target and isotope transporation group has designed and put in use a new target-carrying box weighing 20 pounds less than the one previously used and providing approximately twice as much shielding while carrying targets from the 184-inch cyclotron. This group has also developed an improved hinged target holder for handling powder targets for the 184-inch.

The holder for laminated lead glass windows to be used on beta-gamma processing boxes, the portable serum capper and a modified glove port for Berkeley boxes have been completed. Work is progressing on new and modified manipulators, cave tray chassis and dolly, pipettors, cappers, etc., for a straight-type cave.

Berkeley boxes completed during this period include: one nitrogen atmosphere box, sealed with special doors, well centrifuge type; one standard, completely fitted full recess centrifuge box; a full recess centrifuge box with special lead shielding, requiring fitting with lead bricks and considerably special carpentry work; a standard well centrifuge box, completely fitted; 12/heatlamp sockets and fixtures for use in Berkeley boxes; a stirrer.

The uprights for the decontamination annex north of Bldg. 5 are in process of being installed.

## 11. Plant and Equipment

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Bevatron Building and Equipment. Excavation for building footings is underway and the pouring of concrete was started on approximately September 15, 1949. The horizontal borings have been completed in the slide area and a rather large flow of water is resulting. It is hoped that this will correct this situation. Work is progressing on the assembly of the magnet slabs at the Gilmore shops.

Central Research Laboratory Building. This building is essentially completed and will be occupied starting the week ending September 24, 1949. No further reporting will be made on this job.

Construction of Animal House and Cafeteria. Both of these projects are still in design stage.

Construction of Shops - plumbing, electrical, sheetmetal and salvage. The plumbing and electrical shop has been proceeding nicely. The concrete has been poured (which constitutes the lower floor) and the steel has been erected for the upper floor and roof structure.

Miscellaneous Construction. Warehouse. The building contractor has erected the structural steel and the concrete contractor is preparing to pour the floor slab.

Alterations to Laboratory Buildings. Removal of old equipment has been completed and installation of new equipment started, Rm. 203E, Chemistry Building.

Power Distribution. Pouring of concrete around conduit on the section from the campus switching station to the hill switching station is almost complete. Regarding the leg from the hill substation to the bevatron area, the concrete has been poured in the section of permanent line scheduled for this time and the temporary line adjacent to the Central Research Laboratory is being installed.

Fire Protection. Pipe sections A and B of this project are essentially completed but have been awaiting tests.

University of California Hospital Radiological Laboratory. Tentative drawings have been received and work is in progress on drafting working drawings.

Alterations to Synchrotron Building. This work has been proceeding quite rapidly. Most of the building alterations have been completed and utilities are now being installed.

LMB/9-30-49
Information Division

| PROGRAM | SUBDIVISION | MAN-MONTHS EFFORT | COMMENTS |
|---|---|---|---|
| 184-inch Cyclotron | Operation | 10.5 | |
| | Deflector | 1.8 | |
| 60-inch Cyclotron | - - | - - | Non-Project |
| Synchrotron | R.f. System | .9 | |
| | General | 1.3 | |
| | Injection | .8 | |
| | Magnet Tests and Operation | 5.0 | |
| | Vacuum Chamber | .3 | |
| Linear Accelerator | Linear Accelerator - General | 4.4 | |
| | Van de Graaff - General | 4.0 | |
| | Development | 1.0 | |
| Bevatron | Injector | 3.0 | |
| | Magnet | 2.1 | |
| | Miscellaneous | .3 | |
| | 1/4 Scale Model Development | 6.1 | |
| Experimental Physics | Cloud Chamber | 4.4 | |
| | Film Program | 11.0 | |
| | Ionization Chamber and Crystal Counter | 2.7 | |
| | Neutron-proton Scattering | 1.5 | |
| | Proton-proton Scattering | 3.8 | |
| | Neutron Diffraction | .9 | |
| | Meson Range and Decay Measurement | .8 | |
| | Absolute Cross Section Measurements | 1.8 | |
| | General Physics Research | 16.9 | |
| | Instruments for General Use | 2.6 | |
| | Meson Experiments with Synchrotron | 3.0 | |
| | Scintillation Counters - Research Experiments | 1.1 | |
| | Pair Counter Experiments | 4.6 | |
| | Compton Scattering Experiments with Synchrotron | 2.0 | |
| | Beam Studies with XC Magnet | 1.0 | |
| Theoretical Physics | Synchrotron | - - | |
| | Bevatron | 1.8 | |
| | General Physics Research | 15.7 | |
| Isotope Separation | Nier Spectrometer | 1.2 | |
| | Low Mass Spectrograph | .7 | |

| PROGRAM | SUBDIVISION | MAN-MONTHS EFFORT | | COMMENTS |
|---|---|---|---|---|
| Chemistry, Part A | Chemistry of Transuranic Elements | 10.4 | | |
| | Nuclear Properties of Transuranium Elements | 6.3 | | |
| | Transmutations with the 184-inch Cyclotron | 24.2 | | |
| | Analytical and Service | 13.9 | | |
| Chemistry, Part B | Synthetic and Experimental Organic Chemistry | 7.3 | | |
| | Biological Chemistry | 6.0 | | |
| | Photosynthesis Chemistry | 8.1 | | |
| Chemistry, Part C | Metals and High Temperature Thermodynamics | 8.0 | | |
| | Basic Chemistry, including Metal Chelates | 2.0 | | |
| | Engineering Development of Plutonium Separation | 4.5 | | |
| | Ore Reduction | 3.0 | | |
| | General | 4.5 | | |
| Medical Physics Part A | Metabolism of Plutonium and Allied Material | 9.0 | | |
| | Decontamination Studies | 6.0 | | |
| | Radiochemistry | 5.0 | | |
| | Radioautography | 3.0 | | |
| Medical Physics Part B | Tumor Metabolism | 1.5 | .85 | Consultant Man-Months |
| | Special X-ray Studies, Radioactive Measurements, etc. | 6.7 | 3.15 | |
| | Radioactive Carbon Studies | .9 | - | |
| | Fundamental Medical Research | 5.0 | 3.25 | |
| | Hematology | .4 | 1.25 | |
| | Medical Work with the 184-inch Cyclotron | 5.2 | 1.50 | |
| | Fly Genetics | 4.0 | .25 | |
| | 60-inch Cyclotron Bombardments | .4 | - | |
| | Physical Chemistry | 8.4 | .50 | |
| | Specific Irradiation | 4.2 | - | |
| Health Physics, Chemistry and Medicine | Monitoring and Disposal | 4.8 | | |
| | Salvage, Decontamination, etc. | - | | |
| | Research and Development | 12.0 | | |
| | Film Badge Program | 4.8 | | |
| | Medical Examination Time | 3.1 | | |

This report was done with support from the United States Energy Research and Development Administration. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the United States Energy Research and Development Administration.

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