BROOKHAVEN NATIONAL LABORATORY

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April 1- June 30, 1956

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FOREWORD

This report covers the unclassified research progress of the Laboratory. Abstracts only are given for research activities being reported concurrently in the scientific journals. The appropriate journal or document reference is also given in such cases. A research activity that has not yet reached the stage of journal publication will be reported on in such detail as its progress warrants.

The AEC budget activity numbers for the various researches are given in parentheses at the right hand side of the page, alongside the headings to which they pertain. The symbol (†) is used to designate a supporting activity whose cost is distributed to several research activities.

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PHYSICS DEPARTMENT

Summaries of papers submitted for publication by members of the Physics Department during the period April 1 to June 30, 1956 are given below. Titles of papers presented or submitted for presentation at various meetings during the review period are given at the end of each section. Detailed summaries of these papers will be included in a future progress report when the completed papers are in the process of being published.

High Energy Events, Mesons

(5210)*

PION-PROTON TOTAL CROSS SECTIONS FROM 0.45 TO 1.9 Bev. R. Cool, O. Piccioni,* and D. Clark**. Phys. Rev., in press.

Measurements of the pion-proton total cross section over a range of kinetic energies from 0.45 to 1.9 Bev are described. Positive pions were distinguished from protons of the same momentum by a time-of-flight technique. A liquid hydrogen absorber was used for most of the measurements. Muons, the principal beam contamination, were approximately 10 percent of the pions.

A pronounced maximum for $\sigma(\pi^-, p)$ near 0.9 Bev, which had been noted in our preliminary measurements, is confirmed by data presented here. If this maximum is to be interpreted as a resonance in a single state of angular momentum, the analysis shows that, after subtraction of a term which can reasonably be attributed to nonresonant states, the total angular momentum could be as low as $5/2$ without serious disagreement with experimental data. The possibility of explaining this maximum with a resonant pion-pion interaction as conjectured by Dyson and Takeda is discussed. The measurements of $\sigma(\pi^+, p)$ also give evidence for the existence of a maximum of relatively smaller amplitude at 1.35 Bev.

The differential cross sections in the forward direction for elastic and charge-exchange scattering of pions by protons have been obtained by making use of the dispersion relations.

*Now on leave at Radiation Laboratory, University of California, Berkeley, Calif.

**Present address: Cornell University, Ithaca, N.Y.

PROTON-PROTON INTERACTIONS. II. 1.5 Bev. W.B. Fowler,** R.P. Shutt, A.M. Thorndike, and W.L. Whittemore. Phys. Rev., in press.

One hundred and fifty-two interactions of 1.5-Bev protons have been observed in a hydrogen-filled diffusion cloud chamber. The data indicate an elastic cross section of 20 millibarns, with about 22 millibarns cross section for single pion production and 5 millibarns for double pion production. Most single pion production cases are $p + p \rightarrow p + n + \pi^+$; no definite cases of $\rightarrow D + \pi^+$ or $\rightarrow p + p + \pi^0$ were observed. The median elastic scattering angle is 24° in the c.m.s. Inelastic events have pions emitted isotropically with low momenta, nucleons emitted near 0° and 180° with high momenta. The average relative energy (Q-value) for the p, π^+ pair is 154 Mev.

*For explanation of these numbers, see Foreword.

**Present address: University of California Radiation Laboratory, Berkeley, Calif.

PROTON-PROTON INTERACTIONS. III. 2.75 Bev.* M.M. Block,**† E.M. Harth,** V.T. Cocconi,**†† E. Hart,** W.B. Fowler, R.P. Shutt, A.M. Thorndike, and W.L. Whittemore. Phys. Rev., in press.

Two hundred and twelve interactions of 2.75-Bev protons have been observed in a hydrogen-filled diffusion cloud chamber. The data indicate an elastic cross section of 15 millibarns, with about 9 millibarns cross section for single pion production, 13 millibarns for double, and 4 for triple. There is one example of quadruple pion production. One definite example of the production of heavy unstable particles was observed, and two doubtful cases. The median elastic scattering angle was 19° in the c.m.s. Angle and momentum distributions for inelastic events are consistent with those observed at lower energies.

*Work at Duke University supported by a joint ONR-AEC contract.

**Duke University, Durham, N.C.

***Cornell University, Ithaca, N.Y.

†A portion of this work was performed while the author was on active naval duty at Nucleonics Division, Naval Research Laboratory, Washington, D.C.

††Now on leave at Istituto di Fisica "A. Righi" della Universita degli Studi di Bologna, Bologna, Italy.

PROTON-PROTON INTERACTIONS. IV. INTERPRETATION OF RESULTS AT COSMOTRON ENERGIES.* W.B. Fowler, R.P. Shutt, A.M. Thorndike, W.L. Whittemore, V.T. Cocconi, E. Hart, M.M. Block, E.M. Harth, E.C. Fowler,** J.D. Garrison,** and T.W. Morris. Phys. Rev., in press.

In the absence of numerical predictions based on meson field theory, elastic p-p interactions have been compared with a simple optical model and inelastic ones with statistical theories and considerations based on charge independence. Elastic scattering data are fitted satisfactorily by a spherical interaction region with uniform density, radius 0.93×10^{-13} cm, and absorption coefficient from 4.3 to 2.7×10^{13} cm $^{-1}$. Inelastic interactions provide a confirmatory test of charge independence at 0.81 Bev. Pion multiplicities at 1.5 and 2.75 Bev are higher than predicted by the Fermi statistical theory, but the difference is less than that observed for n-p interactions. The multiplicities observed for p-p interactions are lower than those calculated by Kovacs. Distributions of angle and momentum of particles, and correlation angle and Q-values for pairs of particles, in general agree with the predictions of statistical theory at 0.81 Bev and disagree at 1.5 Bev. The data that are not consistent with statistical predictions suggest that a π -nucleon interaction may affect pion production in an important way, but the data are not sufficiently accurate for definite conclusions.

*Work at Cornell University performed under the auspices of the ONR. Work at Duke University supported by a joint ONR-AEC contract. Work at Brookhaven and Yale University performed under the auspices of the U.S. Atomic Energy Commission.

**Yale University, New Haven, Conn.

Nuclear Reactions and Energy Levels

(5220)

ELASTIC SCATTERING OF NITROGEN BY NITROGEN. C.E. Porter. Phys. Rev., in press.

The differential cross section for the elastic scattering of nitrogen by nitrogen is calculated approximately by using a classical model which has been found previously to account for the elastic scattering of alpha particles by heavy nuclei. The effective mean free path in the collision process is found to be 15 to 35 times smaller than the interaction radius (twice the radius of a single nitrogen nucleus); this finding indicates an extremely strong interaction when two "chunks" of nuclear matter collide.

RADIATION WIDTHS OF NUCLEAR ENERGY LEVELS. J.S. Levin* and D.J. Hughes. Phys. Rev. 101, 1328 (1956).

The highly excited energy levels formed by capture of slow neutrons can be studied by means of the resonances in neutron cross sections as functions of energy. In the present work the radiation widths of levels in heavy nuclei have been measured by means of total cross section curves obtained with the Brookhaven fast chopper. The "shape," "area," and "interference" methods of analyzing the neutron transmission data are described. The radiation widths obtained, together with results of similar measurements, show that radiation widths of levels in the same nuclide are nearly constant, the observed variations from level to level being of the order of experimental error. The radiation widths decrease slowly with atomic weight, except for discontinuities at nuclear shells; these discontinuities can be satisfactorily correlated with variations in excitation energy and level spacing at the shells. The variation of radiation width with excitation energy and level spacing is consistent with theoretical calculations for electric dipole transitions; the absolute theoretical widths are too large by an order of magnitude, however.

*Present address: Los Alamos Scientific Laboratory, Los Alamos, N.M.

SPECULATIONS ON COSMOGONY. M. Goldhaber. Science, in press.

With the discovery of the antiproton, speculations on cosmogony can no longer avoid the question: How can the fundamental particle-antiparticle conjugation symmetry in cosmogony be preserved? It is widely believed that the present average distribution of matter in the universe is the result of an explosion-like expansion from an originally much denser state. Since the part of the universe of which there is direct observational knowledge appears to consist of a "tenuous but continuous distribution of matter" (F. Zwicky, Multiple Galaxies, *Ergeb. exakt. Naturw.* 29, 344 (1956)), it appears unlikely that it contains an appreciable amount of "antimatter", which would be expected to be rapidly annihilated when it collides with ordinary matter, presumably with spectacular emission of visible light and radio-noise. Therefore, if model-cosmogonies are to be constructed which uphold symmetry between matter and antimatter, a preceding state of the universe must be considered from which the present state resulted by a separation of matter from antimatter. Two extreme possibilities are here considered: 1) Nucleons and antinucleons were originally created in pairs, and subsequently "statistical separation" of matter from antimatter took place with most nucleons and antinucleons annihilating each other. 2) Lemaitre's hypothesis of the "primeval atom" is modified with fundamental particle decay as a model. An original particle containing the mass of the whole universe is assumed to have existed and to have decayed into two particles, here called "cosmon" and "anticosmon", of large and opposite nucleonic charge. The cosmon decayed later, possibly through many intermediate steps, into nucleons which in time formed our present expanding cosmos, well separated from a possible "anticosmos". Possible observational tests of these ideas are discussed.

NEUTRON SCATTERING FROM IRON AND CARBON BY TIME-OF-FLIGHT. C.O. Muehlhause, S.D. Bloom, H.E. Wegner,* and G.N. Glasoe. Phys. Rev., in press.

A fixed-frequency cyclotron in conjunction with mps time-of-flight techniques has been used to study elastic and inelastic neutron scattering from iron and carbon in the Mev range. The elastic angular distribution from iron exhibits an optical diffraction type of pattern and the inelastic angular distribution proves to be primarily isotropic except for a slight asymmetry around 90° . The elastic angular distribution from carbon is in essential agreement with previous work.

*Present address: Los Alamos Scientific Laboratory, Los Alamos, N.M.

NUCLEAR SATURATION AND TWO-BODY FORCES. IV. SELF-CONSISTENT SOLUTIONS AND THE EFFECTS OF THE EXCLUSION PRINCIPLE. K.A. Brueckner and W. Wada.* Phys. Rev., in press.

The equilibrium properties of uniform nuclear matter have been studied in previous papers by use of a self-consistency method to determine two-body reaction matrices and the average effective one-particle potential which they generate. In this paper the self-consistency method is simply illustrated with some explicit examples. An investigation is also made of the previously neglected effects of the exclusion principle on transitions to intermediate states. A variational expression is used for the reaction matrix with, as a trial function, the wave function which is exact if the exclusion effect is neglected. Two-body potentials are used which simulate the actual forces, i.e. square wells with a repulsive core of $0.35 \text{ h}/\mu\text{c}$, range of $1.15 \text{ h}/\mu\text{c}$, and depth 98.3 Mev , acting on s-states only. For effective mass values of $0.5 M$ and $0.6 M$, the reaction matrix is found to be appreciably altered, particularly for low relative momentum values. The requirements of self-consistency, however, almost entirely compensate for the change in the reaction matrices so that at normal density in the effective mass approximation the final result for the average binding energy is precisely the same as that obtained when exclusion effects are neglected. The reasons for this simple result are discussed.

Further approximations are discussed which are suitable for more exact computations and which allow inclusion of the exclusion effects, the departures from the effective mass approximation, and the effects of "propagation off-the-energy shell." Approximation methods for a finite nucleus are discussed and a simplified Hartree-Fock method using "pseudo-potentials" (in the sense of Fermi) is described.

*On leave of absence from U.S. Naval Research Laboratory, Washington, D.C.

THE RELATION BETWEEN NUCLEON DENSITY AND NUCLEAR POTENTIAL. K.A. Brueckner. Phys. Rev., in press.

The relationship between nuclear density and potential is determined, account being taken of the saturating character and the finite range of the two-body forces. The former characteristic alone leads to the non-linear relation between nuclear density and potential pointed out by Wilets and accounts for an increase of potential radius over density radius of about $5 \times 10^{-14} \text{ cm}$. The finite range effect is estimated with pseudo-potentials used to represent the two-body interaction operators generated by the two-body potentials. The combined effects of non-linearity and finite range give an increase in the rms potential radius which is very close to that observed experimentally. The fall-off distance of the potential surface predicted is, however, somewhat greater than that empirically determined. It is pointed out that this discrepancy may be removed if proper account is taken of the non-local character of the nuclear potential.

MULTIPLE NEUTRON INTERACTIONS IN RESONANT FOILS. J.E. Draper. Nuclear Sci. Eng., in press.

Experiments on resonance neutron capture, scatter, or fission are often analysed with thin-foil approximations, but because of intensity are better performed with foils of intermediate thickness. To aid in the analysis of the resulting corrections, the probability is calculated that a neutron at normal incidence on a foil will be scattered and undergo a second interaction in the foil. This probability is averaged over a resonance and is compared to the probability of a first interaction. The extension to multiple interactions is considered. An important effect is the change in cross section because of energy loss in elastic scattering. The Doppler broadening of resonances and the effect of potential scattering are also included. The application to the area analysis

of self-indication experiments is emphasized. This general case includes several more restricted cases with resonant detectors and with nonresonant detectors.

DIRECT MEASUREMENT OF THE ENERGY VARIATION OF η FOR U^{233} , U^{235} AND Pu^{239} . H. Palevsky, D.J. Hughes, R.L. Zimmerman, and R.M. Eisberg.*
J. Nuclear Energy, in press.

A technique is described that measures directly the energy variation of η , the number of fission neutrons produced per neutron absorbed. When combined with total cross sections, the method is capable of giving fission cross sections as well. Results are presented in the energy region near thermal, of importance to reactor design, for U^{233} , U^{235} , and Pu^{239} . Comparison with η computed from total and fission cross sections shows good agreement for U^{233} and U^{235} but a disagreement outside experimental error for Pu^{239} . An auxiliary experiment demonstrates that ν , the number of neutrons per fission, is constant with energy in the region of interest for Pu^{239} , hence that the discrepancy cannot be ascribed to a ν variation.

*Present address: University of Minnesota, Department of Physics, Minneapolis, Minn.

NEUTRON RESONANCE PARAMETERS OF U^{235} . V.E. Pilcher, J.A. Harvey,* and D.J. Hughes. Phys. Rev., in press.

The neutron total cross section of ^{235}U has been studied for neutron energies between 1.5 and 60 ev by means of the Brookhaven fast chopper. The transmission data were analyzed by the "area" method and the Breit-Wigner parameters obtained for the resonances up to 35 ev. The observed level spacing of 0.65 ev is the smallest yet reported for any isotope. The best available fission data have been combined with total cross section data to obtain Γ_{γ} . The values of Γ_{γ} are approximately constant and are consistent with those of neighboring heavy nuclei, whereas the values of Γ_n^0 have a very broad distribution similar to that observed in a number of other elements. The distribution of Γ_f values is also rather broad and resembles the neutron widths much more than the radiation widths in this respect. Average values of these parameters are presented, together with a discussion of the implications of these findings for current theories of fission.

*Present address: Oak Ridge National Laboratory, Oak Ridge, Tenn.

IS PARITY CONSERVED IN WEAK INTERACTIONS? T.D. Lee* and C.N. Yang.**
Phys. Rev., in press.

The question of parity conservation in β -decays, and hyperon and meson decays is examined. Possible experiments are suggested which might test parity conservation in these interactions.

*Summer visitor (1956) from Columbia University, New York, N.Y.

**Summer visitor (1956) from Institute for Advanced Study, Princeton, N.J.

Papers Presented

Industrial Nuclear Technology Conference, Chicago
Radiation Sources - - The Next Five Years. D.J. Hughes.

International Conference on Nuclear Reactions, Amsterdam
Neutrons and Nuclear Structure. D.J. Hughes.

THE COMPLETE INCOHERENT SCATTERING FUNCTION FOR CARBON. D.T. Keating and G.H. Vineyard. *Acta Cryst.*, in press. Letter.

An accurate knowledge of the incoherent scattering of x-rays by carbon is of specific importance to the x-ray investigation of radiation damage in diamond being done at Brookhaven, and of general importance because of the frequent use of organic substances to put x-ray intensities on an absolute basis.

Calculations by J. Berghuis *et al.* (*Acta Cryst.* **8**, 478 (1955)) for the coherent scattering showed appreciable divergences from older work, therefore the calculations were extended to the incoherent scattering. The wave functions of A. Jucys (*J. Phys. U.S.S.R.* **11**, 49 (1947)) computed by the Hartree-Fock method with exchange were used in computing the complete incoherent scattering for the configuration $1s^2 2s 2p^3$ and term value 5S .

The calculations, done on the BNL computer, show that the incoherent scattering at small and intermediate values of $\sin \theta/\lambda$ is appreciably less than previously predicted and more in agreement with the values found experimentally by J. Laval (*Bull. soc. franc. minéral.* **62**, 137 (1939)).

RESIDUAL RESISTIVITY VERSUS SHORT-RANGE ORDER IN Cu_3Au . A.C. Damask.* *Intern. J. Phys. and Chem. of Solids*, in press.

The electrical resistivity of Cu_3Au has been measured at 77°K after quenches from various temperatures above T_c , the critical temperature for long-range order. The resistivity decreases with increasing quench temperature up to 485°C, and measurements at 4°K show essentially the same behavior. The origin of this resistance decrease is assigned to short-range order. This decrease of residual resistivity in Cu_3Au with decreasing short-range order is opposite to the results of the author's previous measurements on α -brass. Some implications of these two types of resistivity behavior are discussed.

*Guest scientist from Frankford Arsenal, Philadelphia, Pa.

THE EFFECT OF SHORT-RANGE ORDER ON RESIDUAL RESISTIVITY. J.B. Gibson. *Intern. J. Phys. and Chem. of Solids*, in press.

A general theory, based on the Nordheim approximation, is given for the residual resistivity of binary solid solutions with short-range order but no long-range order. For Cu_3Au this theory predicts an increase of about 18 percent in resistivity with short-range order just above the ordering temperature, in agreement with experiment. For α -brass the agreement is poorer, an 0.4 percent increase in resistivity being predicted in comparison with a 12 percent decrease observed. Qualitative considerations are given for estimating the effect of short-range order for an arbitrary solid solution. In general, the short-range order may be expected to increase resistivity of a binary solid solution whose constituents have different valences when the Fermi surface passes through regions of reciprocal space close to super-lattice reflections.

SHORT-RANGE ORDER COEXISTING WITH LONG-RANGE ORDER IN Cu_3Au . B.W. Roberts* and G.H. Vineyard. *J. Appl. Phys.* **27**, 203 (1956).

Diffuse x-ray scattering from a single crystal of Cu_3Au was observed at $T/T_c \approx 0.995$ where the long-range order parameter, S , equals 0.85. By annealing at low temperatures, nearly perfect order was obtained. A difference curve yields the diffuse scattering attributable to short-range order coexisting with the long-range order state of $S = 0.85$. Analysis of the diffuse intensity in absolute units gives values of

the first three short-range order coefficients. The first coefficient is found to be close to the perfect order value: $a_1 = 0.33$. Within experimental error the observed coefficients fit both the Cowley theory (J.M. Cowley, Phys. Rev 77, 669 (1950)) and a random long-range order model equally well.

*General Electric Research Laboratory, Schenectady, N.Y

Papers Presented

ACA Meeting, French Lick, Indiana

A Neutron Analysis of the Tetragonal $\text{NH}_4\text{H}_2\text{PO}_4$. Leon Tenzer,* B.C. Frazer,** and R. Pepinsky.

American Society of Civil Engineers, Pittsburgh

Effect of Radiation on Material Properties. G.J. Dienes.

*Belgian-American Education Foundation Fellow

**Guest scientist from Westinghouse Research Laboratories, Pittsburgh, Pa

Nuclear Masses

(5220)

THE MASS SYNCHROMETER. L.G. Smith and C.C. Damm. Rev. Sci. Instr., in press.

A novel mass spectrometer with which masses of ions are determined in terms of high harmonics of their cyclotron frequencies is described from both experimental and theoretical viewpoints. Half-width resolution is adjustable electrically over a range of values at present between 10,000 and 25,000 at all mass numbers below 250. By means of a highly precise technique of matching peaks, relative doublet separations in frequency ($\Delta f/f$) equal to those in mass ($\Delta M/M$) are determined with great ease and accuracy on a ratio scaler. Masses have been determined with a precision of better than one part in 10^7 . Sources of systematic error are discussed. Most of these are believed to have been eliminated; however avoidance of them in doublets involving ions formed by dissociation of molecules has so far led to such large reductions of intensity as to restrict greatly the number of such important doublets for which reliable data have been obtainable. It is believed that improvements in the ion source and detecting system can be made which will greatly alleviate this difficulty.

Papers Presented

Symposium on Precision Determination of Nucleon Masses, Max Planck Institute, Mainz, Germany

A Magnetic Time-of-Flight Spectrometer. S.A. Goudsmit

Microwave Techniques and Nuclear Moments

(5220)

THE MAGNETIC MOMENT OF THE NEUTRON. V.W. Cohen, N.R. Corngold and N.F. Ramsey. Phys. Rev., in press.

An experiment has been performed to measure the magnetic moment of the neutron to a greater precision than has heretofore been obtained. The method is somewhat similar to that of atomic beam magnetic resonance using separated oscillating fields. A beam of slow neutrons is polarized by reflection from a magnetized cobalt mirror and then reflected again from a similar mirror used as an analyzer. Between the two mirrors the neutrons pass through a region of uniform magnetic field where

they may become depolarized by a resonant rf magnetic field. The result is a drop in intensity of neutrons reflected from the second mirror. The resonance frequency for depolarization is compared with the proton moment resonance frequency in the same transition region. In order to achieve high resolution of the neutron resonance, the path length of the neutrons in the uniform magnetic field was 110 cm. The measured ratio of resonant frequencies, ν_n/ν_p , equals $0.685057 \pm .000017$. This corresponds to a value of μ_n equal to $1.913148 \pm .000066$ nm.

Book Review

"Molecular Beams" by K.F. Smith. Reviewed by V.W. Cohen. Rev. Sci. Instr., in press.

Experimental Techniques

(5210)

GAS SCINTILLATION FISSION COUNTERS. K.E. Larsson,* R.L. Zimmerman, and H. Palevsky. Rev. Sci. Instr., in press. Letter.

A gas scintillation counter for the measurement of fission events in plutonium has been in operation for several months at Brookhaven. The counter consists of two phototubes inserted at either end of an aluminum cylinder and held by O rings. The foil is placed between the phototubes parallel to the axis of the cylinder. The counter is filled to one atmosphere with spectroscopically pure xenon. After filling, the fission and α pulse heights are observed to diminish with about an eight-day period. Use of a dry ice-acetone trap at the filling tube increases the period to ≥ 70 days. Two types of phototube arrangements have been used: 1) No. 6292 phototubes with a color shifter of 20 mg/cm^2 of p-quaterphenyl evaporated on the face of each tube,** and 2) quartz window-type No. 5819 phototubes with no shifter. The fact that both arrangements exhibited the same time dependence for the pulse size proved that the color shifter was not the principal source of contamination. In both arrangements the ratio, fission pulse height to α pulse height, was the same (~ 20); this finding indicates that both fission and α particles excite the optical levels of xenon in the same way.

*Guest scientist from AB Atomenergi, Stockholm, Sweden.

**Grateful acknowledgment is made to Dr. Ralph Nobles of Los Alamos Scientific Laboratory for preparing these surfaces.

NEUTRON SCINTILLATION COUNTERS. C.O. Muehlhause. Trans. Inst. Radio Engineers, in press.

Existing types of neutron scintillation detectors are reviewed and classified according to composition and mode of detection. Examples in each category are given and their response is related to various radiation field conditions. The principal detector characteristics discussed are their time and pulse magnitude responses as well as the dispersion in these quantities. The need for certain new detector types is indicated and a few speculations are made with regard to this need.

Papers Presented

New Haven APS Meeting

The Isolation of Cyclotron Beam Bunches. J.E. Draper.

COSMOTRON DEPARTMENT

Operations

(†)*

Operations in the last quarter were routine; the only appreciable unscheduled shut-down time was for the repair of the noisy outboard motor bearing of the large motor generator set. The trouble arose because the bearing cradle was 0.012 in. out of round; after machining and reshimming of the pedestal, operation was satisfactory.

Some additional experiments were made on the effect of Van de Graaff energy droop on injection efficiency. It was found that misalignment of the proton beam during a pulse as it entered the inflector could be partially compensated by a pulsed electrostatic deflector following the analyzer magnet; this correction permits a larger injected beam. The effect of energy change on the position of the instantaneous equilibrium orbit was also investigated, and it was clearly shown that proper energy modulation of the Van de Graaff will lead to substantially increased beam intensity. A retractable faraday cup was installed in quadrant number one immediately following the inflector and the transmission of the inflector plates was shown to be 100 percent for proper entrance conditions, although the present energy droop causes the efficiency to fall during a pulse.

A number of new experimental facilities became available. Two pairs of 4-in.-aperture quadrupole strong focusing magnets were received and one pair is now in use in a K-meson beam. A new cover plate for the inside of the south straight section was installed, which supports the beam ejection magnet and allows it to be retracted from the usable machine aperture without breaking the vacuum. The loss of beam at early operation times due to the presence of the ejection magnet near the particle orbits still occurs, but experiments indicate that this effect can be corrected by auxiliary windings on the magnet. A new design for predetermined counters was developed in conjunction with the Instrumentation Division. These devices are now available to experimenters and provide, at any position in the building, four separately controlled timing signals which can be varied in one millisecond steps. The new intermediate level rf system is installed in its final form and provides considerably more flexibility in the amplitude programming of radio-frequency. Liquid hydrogen targets have been modified for angular work by installing thin side walls. The metal targets now have outer walls of 7-1/2-mil mylar and the styrofoam targets have walls consisting of 1 mil brass plus 2 in. styrofoam plus 7 mils mylar. A new deflecting magnet has been installed at the exit of the external shims in order to correct the slight variation of emergent proton beam angle with energy; it is provided with its own dry rectifier power supply. A new experimental water supply and exhaust system has been installed which will provide 400 to 500 gal/min when auxiliary pumps and well system are in operation. A 4-in. emergency hydrogen exhaust system having a double-ended exhaust equipped with a series of lift valves and rupture discs is in operation with the liquid hydrogen bubble chamber.

Several other facilities are in the process of construction. The building to house the new hydrogen liquifier was 80 percent complete at the end of June and should be completed by the middle of July. The liquifier itself has been operated at the NBS laboratory at Boulder, Colorado, to produce 85 to 90 percent parahydrogen at approximately 100 l/hr, and will be shipped to Brookhaven in mid-July. Two more 18 x 36-in. pole tip analyzing magnets are in the process of construction, as well as a focusing and bending magnet for a new K-meson facility.

*For explanation of this symbol, see Foreword.

Two days of operating time were devoted to a complete survey of the radiation produced by the external beam. Some preliminary engineering studies were made of a new experimental area to be constructed around the external beam and of a completely new shielding arrangement around the Cosmotron itself. In order to reduce radiation exposures in the motor generator room, some indicating devices and controls are being removed to remote areas.

Research

(5210)*

Gell-Mann and Pais have shown that if the θ^0 differs from its antiparticle, the application of rigid charge conjugation demands that half of the θ^0 -particles produced cannot decay into two π -mesons, but must decay by another, probably long-lived, mode. Twenty-three decays have now been observed which appear to result from a long-lived neutral particle of about the θ^0 mass which decays into two charged particles and at least one neutral particle. The decays were observed in a 36-in. cloud chamber placed 6 meters from a copper target bombarded by a few times 10^8 3-Bev protons per picture. A sweeping magnet prevents charged particles from entering the chamber. Several of the decay products are identified as pions and several as electrons; it seems that a prominent decay mode is $\pi^+ + e^+ + \nu^0$.

Measurements have been made on the total absorption cross section of Pb and Ca for π^+ -mesons and π^- -mesons with the object of determining whether the neutron radius of nuclei is larger than the proton radius. It appears that if any difference exists it must be quite small.

Previous measurements of the proton-proton angular distribution have been made at 2 Bev and 3 Bev. The distributions appear to be peaked strongly forward. The cross section at 90° is quite small at both energies; hence it appears unlikely that a small very singular core exists in the nucleon.

Further measurements have been made on the production of γ -rays in front of targets bombarded by protons. It seems likely that the γ -rays come from π^0 -mesons which in turn result from the decay of θ^0 -mesons. The production of these γ -rays varies anomalously with the atomic weight of the target nucleus. The production per nucleon is less in deuterium than carbon and very small in hydrogen. A qualitative verification of this latter phenomenon is provided by another experiment. Narrow beams of 2-Bev and 3-Bev protons sent through a hydrogen-filled diffusion chamber seem to produce very few, if any, strange particles.

Further results have been obtained on the production of strange particles by bombarding the protons in a propane bubble chamber with 1.3-Bev π^- -mesons. About 60 events have been observed. All the results are angular correlations consistent with the thesis that the θ 's have spin 0 and the Σ 's and Λ^0 's have spin $1/2$.

*For explanation of these numbers, see Foreword.

Electron Analogue

The realignment of the electron analogue was completed early in April. As reported previously, level misalignments as large as 0.050 in. were discovered; the original level alignment of the machine had been good to ± 0.006 in. Radial misalignments were not as large but had a maximum value of 0.020 in. as compared to the original radial alignment of 0.0035 in. After realignment the analogue was found to be level to ± 0.004 in. and radial alignment was good to ± 0.0025 in.

After realignment, the analogue vacuum tanks were put back in place, the system was thoroughly degaussed, and the machine was brought back into operation. To check "before" and "after" performances an experimental necktie diagram was obtained under dc guide field conditions and without the application of correcting lens fields. One-half integral resonances were found to be as narrow as they had ever been. Vertical integral resonance bands were narrower and it was possible to maintain beam stability beyond the 7th vertical resonance band, an impossibility up to this time. Thus the experimental necktie diagram demonstrated marked improvements in the performance of the analogue due to the realignment.

The experimental program was resumed and an attempt was made to determine experimentally the magnitude of the nonlinear field components of the machine by effectively changing the momenta of electrons on the equilibrium orbit and observing the resultant changes in betatron oscillation frequencies. A successful attempt was then made to make the betatron oscillation frequency independent of the momentum changes by counterbalancing the effects of the nonlinearities by means of sextupole correcting lenses.

The beam was then accelerated and the accelerated beam intensities were as good as and occasionally better than those available before the analogue misalignment. The characteristics of the beam at and after phase transition were studied as functions of both the field nonlinearities and the timing of the phase jump. The widths of the electron bunches were not found to be strongly affected by variations of these parameters.

In the analogue the electrons undergo only a few phase oscillations during their acceleration cycle. This is not the case in the AGS; therefore it is of interest to check whether repeated crossings of resonances due to a relatively high ratio of phase oscillation frequency to revolution frequency will affect the beam stability. AGS phase oscillation conditions were simulated in the analogue by applying an ac field to one quadrupole lens and observations were made with unaccelerated beams. Intensity losses at resonances were shown to be only slightly higher with the equivalent of very high phase oscillation frequencies (20 to 30 kv/sec) than those observed with the natural analogue phase oscillation frequency of 5 kc/sec.

At the end of June the analogue was shut down and put on a stand-by basis. The accumulated data are being analyzed and the results will determine whether the machine will be reactivated for a brief interval.

Magnet

Magnet Model No. 4 was assembled from 5-in.-wide blocks of laminations. The magnetic behavior of this assembled model was found to be very similar to that of the

*For explanation of this number, see Foreword.

individual blocks. The integration of the blocks thus seems to have no smoothing-out effect on the magnetic characteristics of the magnet. An intense effort was made to obtain the maximum amount of data from Magnet Model No. 4. Gradients, fields, and end effects were measured under dc and dynamic conditions as functions of azimuth, radius, and magnet current. Model vacuum-chamber sections consisting of 0.078-in.- and 0.093-in.-thick Inconel were placed in the magnet gap to test the effect of the eddy currents in the chamber walls on the fields inside the gap. A considerable quantity of data has been accumulated and is being analyzed.

The search continues for the best steel for the AGS magnet core. Considerably more magnetic data have been obtained from various steel firms and from measurements on Magnet Models No. 3 and No. 4. Only two types of steel are still under consideration, low silicon electrical grade and low metalloid steels. Fabrication of the 240 AGS magnets is complicated and fabrication techniques such as heat treatments and welding can affect the magnetic properties of the steel. Several fabrication techniques have been suggested by various manufacturers. These can be roughly classified into two groups: fabrication by chemical bonding methods, and fabrication by strictly mechanical means. Negotiations are now in progress to make at least one full-scale magnet model by each of these two fabrication methods. For this purpose, 20 tons of hot-rolled and 15 tons of cold-rolled M-36 steel have been purchased from the U.S. Steel Corporation, and an additional 15 tons of cold-rolled M-36 steel have been obtained from the Allegheny Ludlum Steel Corporation.

A new magnet pole contour based on data from Magnet Models No. 1 through No. 4 has been designed; it is expected to be a close approximation of the final pole contour. A half-scale model of the new pole tips has been built and will be tested on the half-scale dc magnet model.

The power group drew up preliminary specifications for the final AGS magnet power supply based on the final over-all dimension of the magnet, and discussed them with various manufacturers of heavy power equipment. The final specifications are now being prepared and will be submitted to the power manufacturers early in August with invitations to bid.

Linac

Work on the design of the linac continued. One significant change has been made: the diameter of the tanks has been increased from 90 cm to 92 cm with a consequent considerable reduction in the drift-tube diameters which is desirable because the low-energy drift tubes were becoming unwieldy. The design of the first of the eleven linac tanks has been completed, and design of all other linac components is making good progress.

The construction of the precision linac model was completed. This model is a section of the linac tank. Drift tubes under test are in one end plane of the cavity; the length of the section is established by means of a movable shorting plane at the other end. The cavity is used to test calculations relating drift-tube shape to resonant frequency. Adequate data on one drift-tube configuration have been obtained and show close agreement with the calculated values. A check of a second drift-tube shape is now under way and a third drift-tube shape is being fabricated. Test measurements made with ball tuners in the precision model established that these tuners are able to cover adequate frequency ranges. The computer program to calculate all drift-tube shapes is being continued at the New York University UNIVAC installation.

A prototype pulser and power supply for the focusing quadrupole magnets has been built and tested. It is now planned to operate these magnets in groups. Thus, for the 120 focusing magnets 30 pulsers and 5 power supplies will be required. The maximum

pulsing rate is expected to be 5 pulses/sec and the power supplies are designed for maximum currents of about 100 amp.

Construction of the power model is nearing completion. The power system for this model, a power oscillator - amplifier system utilizing 3W10,000A power triodes, has been built.

A development contract was executed with the Eitel-McCullough Company for the development of a 5-megawatt, 200-mc klystron, delivery of which is expected early in 1957. Meanwhile, construction of a prototype of the 10-kw klystron driver was started at BNL. Other intermediate level linac rf circuitry is now under development.

Studies of schemes to take the proton beam from the linac into the synchrotron were started, and proton trajectories through the fringing fields of the synchrotron magnet were calculated in detail.

Radio-frequency

The design of the second model cavity was completed and this cavity is now being fabricated. About 50 percent of the necessary ferrite rings have been received. Tests have indicated that the μQ products of these rings are higher than the minimum μQ specified; it appears that quality control at the factory has improved considerably. Tests on the remaining part of the ferrite order will show whether this assumption is correct or whether the improved quality of the rings tested to date is the result of statistical fluctuations.

Construction of the model power amplifier was completed. The amplifier, a six-stage push-pull shunt-peaked system utilizing EIMAC M6424 tetrodes in its final amplification stage, has been tested on an artificial load. The Q values of the dummy load over the range of 1.5 to 4.5 Mc/sec are lower than the equivalent Q values of the ferrite cavities. This produced some ripple on the output wave front of the amplifier; however, the low-level signals of 1.5 v were amplified to the required output of 8 kv without difficulty, and no signs of spurious resonances have been observed.

The AGS power amplifier is being redesigned to take advantage of the higher power rating tubes recently made commercially available. Since these tubes are needed in much smaller numbers than those now used, the new model will be considerably smaller than the present one.

Structures

A settlement was reached in the jurisdictional dispute which held up the construction of the Service Building for two months, and work on the building was resumed in full force. At present 68 percent of the construction is completed and occupancy is planned for early October.

Bids for the magnet foundation pile driving were received in May and the contract was awarded. Driving of bearing and sheet piles commenced in May and was completed in June, about one month ahead of schedule. In the meantime, design of the concrete magnet tunnel was completed and the contract for its construction awarded. Work on the magnet tunnel is expected to start early in the next quarter.

The design of the Target Building and the magnet support girder was finished. Bids were received for the fabrication of the girder and are now being reviewed.

The following abstracts summarize work submitted for journal publication or presentation at scientific meetings by members of the Chemistry Department, including visitors, during the period April 1 to June 30, 1956. The subjects covered lie in the fields of: radiation chemistry; neutron diffraction; nuclear and radiochemistry; biosynthesis; and physical chemistry.

OXIDATION OF FERROUS SULFATE BY IONIZING RADIATIONS FROM (n, α) REACTIONS OF BORON AND LITHIUM. R.H. Schuler and N.F. Barr. Submitted to J. Am. Chem. Soc. Also submitted for presentation at the Am. Chem. Soc. Meeting, Atlantic City, N.J., September 1956.

The high degree of reproducibility of irradiations carried out in the thermal neutron facility of the Brookhaven reactor makes possible the study of details of the radiation chemistry of the very densely ionizing radiations produced in (n, α) activation of boron and lithium. The respective 100-ev yields for these radiations have been found to be 4.22 ± 0.08 and 5.69 ± 0.12 for 1 mM ferrous sulfate in aerated 0.8 N sulfuric acid solution, and 3.77 ± 0.10 and 4.10 ± 0.10 in de-aerated solution. From the measurements on aerated and de-aerated solutions, a value of 3.6 is calculated for the net water decomposition yield. This may be compared to values of 3.6 determined for cyclotron radiations and 4.5 for fast electrons. From the above values for aerated solutions, a yield of 6.7 is estimated for the 2.7-Mev tritium recoil produced in the neutron activation of lithium. The ferrous oxidation yields are increased slightly by saturation of the solutions with oxygen and also by an increase of the ferrous concentration from 1 to 10 mM.

AN APPARENT ANISOTROPIC DEBYE-WALLER FACTOR IN CUBIC CRYSTALS. R.J. Weiss,* J.J. DeMarco,* G. Weremchuk,* L. Corliss, and J. Hastings. Submitted to Phys. Rev.

Neutron and x-ray diffraction studies on α -brass (70-30 f.c.c.) have revealed that the integrated intensities are reduced by a Debye-Waller temperature factor, $\exp(-2B(\sin \theta/\lambda)^2)$, where B is not only a function of the characteristic temperature, θ , and the absolute temperature, T, but also a function of crystal direction, contrary to present theories. The effect is very marked in comparing the 222 and 400 peaks as to both their relative intensities and their changes in intensity with temperature from that of liquid nitrogen to room temperature.

*Watertown Arsenal, Watertown, Mass.

DECAY OF NEUTRON-DEFICIENT ISOTOPES OF Pd AND Rh. S. Katcoff and H. Abrash.* Submitted to Phys. Rev.

Pd isotopes of masses 98, 99, and 101 were prepared by α -particle bombardment of ruthenium. The radiations of these isotopes and of their Rh daughters were investigated with a scintillation coincidence spectrometer. Rh^{98} decays with a half-life of 8.7 ± 0.1 min by emission of 2.5 ± 0.2 Mev positrons in coincidence with 650 ± 10 kev γ rays. Its Pd^{98} parent was shown by successive daughter extractions to decay with a half-life of 17.5 ± 0.5 min. Rh^{99} (4.7 ± 0.1 hr) showed 0.74 Mev positrons (10 percent) in coincidence with 335 ± 10 kev γ rays (70 percent). Other γ rays were observed at 615 ± 15 kev (20 percent), 890 ± 20 kev (weak line coincident with 335 kev

*For explanation of these numbers, see Foreword.

γ), 1.26 ± 0.03 Mev, and 1.41 ± 0.04 Mev (weak). Pd^{99} (21.6 ± 0.6 min) was identified by successive Rh daughter extractions. Its maximum positron energy is 2.0 ± 0.1 Mev and the following γ rays were observed: 140, 275, 420, and 670 kev. The 140 kev γ ray is the most intense and the 420 kev peak represents two γ rays of about the same energy in cascade. Rh^{101} (4.7 ± 0.2 days) decays by electron capture followed by emission of 312 ± 10 kev γ rays. Pd^{101} (8.5 ± 0.3 hr) emits 0.58 ± 0.04 Mev positrons (4 percent) by decay to the ground state of Rh^{101} . The γ rays observed were at 288 kev (15 percent), 590 kev (15 percent), 720, 1190, and 1280 kev (the last three less intense). The photopeak at 288 kev represents two coincident γ rays of about the same energy. Tentative spin and parity assignments were made for the ground states of the nuclides investigated. Mass assignments were confirmed by a study of the relative yields of the various radioactive isotopes as the bombarding α -particle energy and isotopic composition of the Ru target were varied.

*Summer student (1955) from Harvard University, Cambridge, Mass.

TRITIUM COUNTING IN GLASS PROPORTIONAL COUNTING TUBES. D.R. Christman. Submitted to Chemist Analyst. Note.

In their original paper on the subject (Rev. Sci. Instr. 21, 158 (1950)), Bernstein and Ballentine encountered large memory effects in the counting of tritium in glass proportional counting tubes with silver cathode surfaces. They believed, probably correctly, that the difficulty lay in action of the tritium on the glass parts of the tubes rather than with the silver wall.

Since these glass counting tubes are in routine use in this laboratory for the counting of C^{14} as carbon dioxide, it seemed desirable to find conditions under which tritium could be similarly handled. It has been found that, under dry conditions, tritium can be counted in these tubes as hydrogen or methane, or a mixture of the two, with no untoward memory effects. Ordinarily the tubes can be pumped out to the original background within about one-half hour on a vacuum line with a mercury diffusion pump. Care must be taken to exclude water completely, as its presence ruins the counting characteristics of the sample in the tube and makes it difficult or impossible to decontaminate the counting tube.

The procedure of Wilzbach, Kaplan, and Brown (Science 118, 522 (1953)) has been found to yield a dry mixture of hydrogen and methane which is quite satisfactory for this purpose. In this method, organic compounds undergo combustion in a sealed tube over nickel oxide and an excess of zinc. At the end of the combustion the sample can be introduced into the counting tube by means of a Toepler pump, the last portion being swept in by the filling gas which is being introduced, to bring the total pressure in the counting tube to one atmosphere. The measuring bottle for the filling gas has been previously described (Van Slyke, Steele, and Plazin, J. Biol. Chem. 192, 769 (1951)). The use of P-10 gas (90 percent argon + 10 percent methane) as the filling gas is recommended; this has also been previously described (Christman, Day, Hansell, and Anderson, Anal. Chem. 27, 1935 (1955); Sinex, Plazin, Clareus, Bernstein, Van Slyke, and Chase, J. Biol. Chem. 213, 673 (1955)). The only portion of the activity not introduced into the counting tube is the 1.5 percent retained in the combustion tube (Wilzbach, Kaplan, and Brown, Science 118, 522 (1953)).

If similar tritium samples are counted in tubes of varying cathode length and the reciprocal of the cathode length is plotted against the counting rate per cc of cathode volume and the curve extrapolated to infinite cathode length (Bernstein and Ballentine, Rev. Sci. Instr. 21, 158 (1950)), the counting efficiency within the cathode volume for tritium samples is found to be 97 to 98 percent in tubes with a cathode volume of about 85 cc and a total volume of about 100 cc. The standard deviation of the results for a series of seven runs on the same sample of tritium water was ± 1.9 percent,

which compares favorably with the results of counting C^{14} in these counting tubes (Christman and Wolf, Anal. Chem. 27, 1939 (1955)).

This method has been used by several different investigators in this laboratory and has been found to give generally satisfactory results (Rowland, Turton, and Wolfgang, J. Am. Chem. Soc. 78, 2354 (1956)). The main time-consuming factor is the weighing of the sample and the sealing-off of the individual combustion tubes, since the loading of the sample into a counting tube can be accomplished in 10 to 15 min. The tubes can be counted within 30 min of their loading, the gases having become sufficiently mixed in that time.

Gas-phase proportional or Geiger counting is one of the two most sensitive methods of counting tritium; it is comparable to ionization-chamber methods in this respect. As with C^{14} (Christman and Wolf, Anal. Chem. 27, 1935 (1955)), a disintegration rate of 10 disintegrations/min should be detectable with a standard deviation of about ± 10 percent, if the counting is done with sufficient care.

NEUTRON ACTIVATION STUDY OF MEDITERRANEAN POTSDHERDS. E.V. Sayre and R.W. Dodson. Submitted to Am. J. Archeology.

The artificial radioactivity produced in pottery fragments through bombardment by neutrons has revealed information that can be correlated to the regions of origin of the sherds. Following a 30-sec exposure in the Brookhaven nuclear reactor, sherds from Italian, Greek, and Near Eastern sites all emitted gamma-ray radiation originating predominantly from sodium and manganese contained within them. The ratio of the activity due to manganese to that due to sodium was constant within approximately 20 percent in sherds from the same site, whereas it differed by as much as a factor of four in sherds from different sites. The general procedure by which this initial correlation has been obtained should be susceptible to further development so that other correlations might be observable and the limits of reliability become more rigorously defined.

BIOSYNTHESIS OF THE PYRIDINE RING OF NICOTINE.* R.F. Dawson,** D.R. Christman, R.C. Anderson, M.L. Solt,** F.D'Adamo,** and U. Weiss.** Submitted to J. Am. Chem. Soc. Letter.

Although carboxyl- C^{14} -labeled nicotinic acid was not incorporated into the nicotine produced by sterile cultures of excised roots of Turkish tobacco (Dawson, Christman, and Anderson, J. Am. Chem. Soc. 75, 5114 (1953)), nicotinic acid labeled in the ring with tritium and another preparation labeled in all positions with C^{14} have been found to be incorporated to a high degree in the nicotine produced by such cultures. The labeled acids were produced by neutron irradiation of a mixture of Li_2CO_3 and nicotinic acid, and of nicotinamide, respectively (Wolfgang, Rowland, and Turton, Science 121, 715 (1955); Anderson, Penna-Franca, and Wolf, BNL Quarterly Progress Report, October 1 - December 31, 1954)). At different feeding levels of nicotinic acid, the nicotine produced in the presence of the tritiated acid was formed from the labeled acid in amounts of 60 percent and 75 percent of the total amount produced; and the nicotine from the C^{14} -labeled acid was formed in an amount equal to 23 percent of the total. Oxidation of one preparation of tritiated nicotine to nicotinic acid with aqueous $KMnO_4$ gave nicotinic acid of which the specific activity was 98 percent of that calculated from the activity of the nicotine as nicotinic acid with the pyrrolidine hydrogens assumed to be inactive. It is therefore probable that the pyridine ring of nicotine, and possibly also of the related tobacco alkaloids (myosmine, anabasine, anatabine, etc.), arises from the pyridine ring of nicotinic acid, the carboxyl group being lost in some manner during the process.

*Joint contribution from the Departments of Chemistry and Biology.

**Department of Botany, Columbia University, New York, N.Y.

THE THERMODYNAMIC THEORY OF IRREVERSIBLE PROCESSES. I. THE BASIC MACROSCOPIC CONCEPTS. D.G. Miller. Submitted to Am. J. Phys.

The foundations of the thermodynamic theory of irreversible processes are presented in macroscopic terms. The concept of entropy production in systems with gradients is discussed in relation to classical thermodynamics and to the need for new hypotheses. The entropy production is computed in some simple cases, and it is found that its factors can be related to well-known linear laws such as Ohm's. It is shown on experimental grounds that the linear laws must be generalized in complex cases involving interacting flows. Further recourse to experiment shows the Onsager relations to be valid. The range of validity of the theory is discussed.

REACTOR DEPARTMENT

Foreword and General Notes

Research facilities continue to be utilized to full capacity by all the scientific departments of the Laboratory as well as by various guest organizations such as Bell Telephone Laboratories, Inc., California Research Corporation, Columbia University, General Electric Company's Research Laboratory, the Mine Safety Appliances Company (for the Navy's BuShips), Rensselaer Polytechnic Institute, Esso Research and Engineering Company, and Westinghouse Electric Corporation.

During this quarter negotiations were completed for the transfer of the BNL shielding program and facilities to administration and sponsorship by the U.S. Air Force's Wright Air Development Center. The scientific staff of the shielding group is now attached to WADC with a guest status at Brookhaven. WADC will reimburse the Laboratory for services and supplies furnished, under account number 5983.

Special Meeting

A member of the Department was chairman of one of the sessions of the Joint U.K. - U.S. Conference on Reactor Hazards recently held in Chicago.

Project Colombo

(5982)*

Marvin Fox, temporarily relieved of his responsibilities as Chairman of this department, was appointed manager of Project Colombo, a special study undertaken by the Laboratory for the International Cooperation Administration of the U.S. Department of State. This study was initiated to determine the scope and set up the ground rules, organization, and basic plans for the establishment of a nuclear research center in the Philippine Islands, which has been offered by the United States to the Colombo Plan nations of southeast Asia on a multilateral basis under the President's Atoms-for-Peace Plan.

To execute the study, a two-part team was organized consisting of a field team, led by the Project manager, and a home team, of which Dennis Puleston was appointed manager. The field team, composed of specialists in the physical, life, and social sciences, as well as representatives from industry and the State Department, spent ten weeks on an extensive tour of the Asian Colombo Plan nations conferring with government and scientific leaders to determine the extent of their interest, cooperation, and requirements in connection with the Center.

During this period the home team conferred with specialists in this country and collected the necessary data and background information to complement the findings of the field team.

In consultation with Philippine leaders, the field team, supplemented by an architect-engineer group under subcontract with the Laboratory, made a final site selection and preliminary engineering studies for the Center, subject to negotiation with the Philippine government concerning the availability of the chosen site.

A final report recommending detailed plans for the Center covering its organization, facilities, operation, scope, functions, and nature is being prepared by both teams for submission to ICA. This report is expected to serve as a basis for the formal

*For explanation of these numbers, see Foreword.

plans which the United States will present for acceptance to the Colombo Plan nations at their annual meeting in New Zealand later this year.

Operations

(†)*

The reactor maintained a power level of 24 Mw for a total of 1,827 Mwd. Shutdowns for maintenance and research equipment changes consumed 11 percent of the total time. As of June 30, the accumulated total equaled 39,024 Mwd.

Among the less routine jobs performed during shutdowns in May were disassembly of the fast neutron chopper from position T-3 on the top face, and installation of a new facility for the Physics Department, a slow neutron chopper located at position T-8 on the top face. This installation required the drilling of a 16-in.-diameter hole, 28 in. deep into the graphite.

Enriched Fuel Project

(†)

A hazards report, covering operation and control of the BNL reactor when loaded with highly enriched uranium, was completed and submitted to the AEC for review.

Delivery of 300 fuel elements, previously scheduled for the end of May, has been postponed, mainly because of delays in allocation and procurement of SS materials. Delivery is now expected near the end of September at the earliest.

Medical Research Reactor

(†)

Ground has been broken for the new hospital complex and the following contracts have been awarded: 1) to Daystrom, Inc. for the reactor proper including the reactor tank, grid plate, fuel elements, control rods, control rod drives, instrument boards, and console; 2) to Baldwin-Lima-Hamilton Corp. for the shutter and accessory components; and, 3) to Malan Construction Co. for the building to house the reactor with all standard equipment. The hazards report covering operation of this facility has been completed for AEC review.

Neutron Physics

(5220)

Members of the group spent a week at ORNL for consultation and discussion concerning nuclear alignment experiments, availability of stable isotopes, and work on magnetic moments.

Considerable effort has been devoted to the development of a training program in basic spectrographic techniques and experimentation for the summer student program.

One member of the group was invited to participate in the Conference on Nuclear Reactions sponsored by the International Union of Pure and Applied Physics in Amsterdam, Holland, to be held from July 2 to 7. After this meeting he will participate in a classified session at Harwell and visit various European scientific installations.

Cooperative Programs: Investigations by the General Electric Spectrometer Group

THE ANTIFERROMAGNETIC STRUCTURES OF MnO, FeO, CoO AND NiO. W.L. Roth. Presented at ACA Meeting, French Lick, June 1956.

The antiferromagnetic structures of the monoxides of the transition elements have

*For explanation of this symbol, see Foreword.

been reexamined by powder neutron diffraction methods, and in the case of nickel oxide by neutron diffraction from single crystals.

The neutron diffraction data confirm the crystallographic distortions below the antiferromagnetic Curie temperature: MnO and NiO are rhombohedral with $\alpha > 60^\circ$, FeO is rhombohedral with $\alpha > 60^\circ$, and CoO is tetragonal with $c/a=1$.

By indexing the magnetic superlattice reflections on the distorted unit cell, it is possible to demonstrate for CoO, and probably for MnO and NiO, that the four magnetic sublattices are correlated so that the spins in each (111) plane are parallel, and the spins on neighboring (111) planes are antiparallel. Identification of the spin direction is preliminary, but tentatively the following assignments are made: MnO [111] or (111); CoO [112]; NiO (111); FeO [111].

The iron oxide samples are non-stoichiometric, and the nuclear intensities demonstrate the presence of iron vacancies. From the magnetic intensities it appears that the non-stoichiometry results in the formation of "paramagnetic islands" consisting of a vacancy and two associated ferric ions.

NEUTRON DIFFRACTION STUDY OF THE $\text{Fe}_2\text{O}_3 - \text{Cr}_2\text{O}_3$ SYSTEM. J.S. Kasper and B.F. Decker. Presented at ACA Meeting, French Lick, June 1956.

The crystal and magnetic structures of four different compositions in the $\text{Fe}_2\text{O}_3 - \text{Cr}_2\text{O}_3$ system have been determined from neutron diffraction patterns of powdered specimens. There is complete solubility over the entire range of composition, with only gradual variation of structural parameters. Accordingly the magnetic structures are of interest, since the components Fe_2O_3 and Cr_2O_3 have different antiferromagnetic structures.

The following compositions were studied:

50% Fe_2O_3 - 50% Cr_2O_3	298° and 77°K
40% Fe_2O_3 - 60% Cr_2O_3	298°K
25% Fe_2O_3 - 75% Cr_2O_3	298° and 77°K
10% Fe_2O_3 - 90% Cr_2O_3	298° and 77°K

At 298°K for all compositions the structure is rhombohedral and there is a continuous variation of the parameters u (oxygen) and v (metal ion) with composition. There is a random distribution of Fe^{+++} and Cr^{+++} , and all compositions are antiferromagnetic. The antiferromagnetic structure is the same as that of Fe_2O_3 up to and including the composition 25% Fe_2O_3 - 75% Cr_2O_3 ; at 10% Fe_2O_3 - 90% Cr_2O_3 , the magnetic structure is that of Cr_2O_3 .

At 77°K, the patterns of the latter two compositions show additional peaks for the magnetic structure. These peaks correspond to super-cells which are derivable from the room temperature rhombohedral cell.

STUDIES OF COMPLEX STRUCTURES OF TRANSITION METALS BY NEUTRON DIFFRACTION. J.S. Kasper. Presented at ACA Meeting, French Lick, June 1956.

The manner in which neutron diffraction can profitably supplement x-ray diffraction in the study of complex structures will be discussed, with reference to inter-metallic compounds of transition elements of the first row. The σ -phase and α -manganese structures are particular examples. The closeness of x-ray scattering factors of the component elements has made it difficult in x-ray studies to ascertain whether there is ordering of atoms in such structures. The marked differences in nuclear scattering factors for those situations, on the other hand, has made it possible to determine the nature and degree of ordering by neutron diffraction.

Also, the occurrence of magnetic structures for some cases allows further structural deductions to be made from the neutron data.

Isotope Distribution, Irradiation Services, and Special Materials (5100)

During the quarter there was a heavy demand for radioisotopes and irradiations by BNL research groups, and in addition 130 outside customer orders were filled. Charges on these orders amounted to \$45,000, not including the rental of space to outside users which came to \$59,000. It should be noted that the first figure included the shipment of several kilocurie sources.

A member of the group attended the Commission's annual meeting of Materials Management Representatives in Washington, D.C. in May.

The annual survey of BNL material inventory and procedures is currently being conducted by AEC representatives.

Meteorology Group

Analysis and Processing of Data (6440)

Work has continued on a general UNIVAC program for the various types of power spectra and, in addition, a new program for the computation of effluent concentrations from any point source has been completed and corrected. This program utilizes the Bosanquet, Carey and Halton equation (1950) to predict the thermal and jet rises of a given effluent emission, and subsequently computes concentrations for any selected points by means of the Sutton equation (1947). This program permits very rapid analysis of new problems, and it will also be used to evaluate dispersion parameters in the current and past oil-fog tests.

The basic plans for converting the entire meteorological facility to automatic punch card recording have been completed. The detailed selection of components and circuitry is now being accomplished with the cooperation of the Instrumentation Division.

Oil-Fog Tests (†)

The 1956 series of dispersion tests was begun on April 10 with a run utilizing a complete set of densitometers and filters at ground level. By the end of the quarter two more successful ground-level tests and two airborne runs had been completed. The data from these will not be completely processed at present, but will probably be held until the winter of 1956-57 for full analysis.

(†)

THE ANNUAL VARIATION OF SUBSOIL TEMPERATURES ABOUT A 600-FOOT-DIAMETER CIRCLE. I.A. Singer and R.M. Brown. Trans. Am. Geophys. Union, in press.

To assist engineers in the computations of thermal stresses, and in the selection of an economic depth for placement of a new proton synchrotron, the Meteorology Group predicted and arranged to measure the annual variations of subsoil temperatures. The predictions were compared to observed values at depths of 2.5, 5, 10 and 20 ft at four stations located on a circle having a diameter of 600 ft. The thermal diffusivities were computed from classical heat conduction equations and compared to standard values.

Gustiness Analyzer (†)

The initial model of this instrument was completed about a year ago, and is described in BNL Quarterly Progress Report April 1 - June 30, 1955. The device

succeeds in differentiating the several gustiness classifications used in Brookhaven dispersion studies, and can be used as a substitute for the present visual interpretation of the recorder charts. So many inquiries have been forthcoming concerning an automatic means of differentiating gustiness classes that the instrument is being redesigned to make use of commercially available components wherever possible. The new model will eliminate many of the cumbersome parts embodied in the original, and will record directly on an Esterline Angus or Brown chart.

DAF Meteorology Study

(†)

This project is now entering its final stages. The bulk of the machine and computer processing is done, and much of the preliminary analytical work has also been completed. Preparation of the final report will begin within a month or two.

NUCLEAR ENGINEERING DEPARTMENT

(4520)*

RESONANCE ESCAPE PROBABILITY MEASUREMENTS IN SLIGHTLY ENRICHED URANIUM - LIGHT WATER LATTICES. R. Sher. Presented at Am. Nuclear Soc. Meeting, Chicago, June 1956.

The resonance escape probability, p , in several lattices of slightly enriched (~ 1 percent U^{235}) uranium rods in light water moderator has been measured. The variation of p with rod diameter, rod spacing, etc. will be discussed. These measurements, combined with previous measurements of buckling, migration area, fast effect, and thermal utilization, permit a value of η to be inferred, and this will be compared with that from similar measurements on the Brookhaven reactor.

(4520)

FAST FISSION MEASUREMENTS IN THORIUM-URANIUM - LIGHT WATER LATTICES. G.A. Price. Presented at Am. Nuclear Soc. Meeting, Chicago, June 1956.

The ratio of fast fissions to thermal fissions has been measured in 0.387-in. thorium rods, enriched with 2 percent U^{235} and moderated with ordinary water. Water-to-thorium volume ratios were varied from 1:1 to 4:1. The fission-product catcher technique was used to measure fission ratios. The effect of fast fissions on the k_{∞} of these lattices will be discussed, and comparisons will be made with earlier results obtained with slightly enriched uranium - ordinary water lattices.

(4520)

CRITICAL EXPERIMENTS ON A LIGHT WATER MODERATED GRAPHITE REFLECTED ASSEMBLY. K.W. Downes. Presented at Am. Nuclear Soc. Meeting, Chicago, June 1956.

The reactor physics group at BNL has recently completed a series of critical experiments on a graphite reflected, light water moderated reactor. Data presented will include critical mass and flux distributions for various changes of the reactor core.

(4107.1)

PROCESS FOR FISSION-PRODUCT REMOVAL FROM URANIUM-BISMUTH REACTOR FUELS BY USE OF FUSED-SALT EXTRACTION. O.E. Dwyer. Am. Inst. Chem. Engrs. J. 2, 163 (1956).

The liquid metal fuel reactor under development at Brookhaven uses a fuel consisting of a solution of U^{233} , Mg, and Zr in liquid bismuth. For a power-breeder thermal reactor, high neutron economy is essential, therefore fission products which are high neutron capturers must be kept at a low concentration in the fuel. Roughly 45 percent by weight of the fission products can be continuously removed from the fuel by salt extraction with alkali and alkaline earth fused-salt mixtures. These fission products contain the highly "poisonous" rare earths. This paper presents a discussion of process-design considerations and proposed flow sheets.

(4107.1)

PRELIMINARY KINETICS CALCULATIONS FOR AN EXPERIMENTAL LIQUID BISMUTH CIRCULATING FUEL REACTOR. J.A. Fleck, Jr. Presented at Am. Nuclear Soc. Meeting, Chicago, June 1956.

The reactor system consists of a primary loop through which a uranium-bismuth solution circulates, and a secondary closed-circuit air loop. The temperature coefficient of this reactor is negative and is composed of two parts: 1) a coefficient attributable to the expansion of the fuel, which is assumed to take place instantaneously, and 2) a moderator coefficient which is delayed and operates with a time constant of

*For explanation of these numbers, see Foreword.

about 20 sec. The linearized stability of the system is examined, and the nonlinear kinetic equations are integrated numerically to obtain the transient behavior of the system.

(4107.1)

THE DIFFUSION OF PROTACTINIUM IN THORIUM BISMUTHIDE. M.B. Brodsky and R.J. Teitel. Presented at Metallurgy Information Meeting, Ames, Iowa, May 1956.

The movement of protactinium from thorium-bismuthide intermetallic compound into the dispersing phases of liquid bismuth and lead-bismuth eutectic has been studied. The study was made as a function of time, temperature, particle size, and protactinium concentration. The relative contributions of diffusion and particle growth on the observed movements have been considered.

(4107.1)

PRODUCTION OF THORIUM-BISMUTH DISPERSIONS. J.S. Bryner, R.J. Teitel, and M.B. Brodsky. Presented at Metallurgy Information Meeting, Ames, Iowa, May 1956.

Methods will be described by which dispersions of equiaxed particles of thorium bismuthide in liquid bismuth have been produced on a laboratory scale. These methods include various modifications of the reaction of solid thorium with liquid bismuth, and a new method by which the dispersions can be produced from a solution of thorium in liquid bismuth. The scale-up of these methods to produce large batches will be discussed.

(4640)

KINETICS OF GRAFT COPOLYMERIZATIONS. D.J. Metz. Presented at Gordon Research Conf., New Hampton, N.H., July 1956.

A wide variety of graft copolymers have been prepared by the irradiation of a polymer in the presence of a monomer with cobalt-60 gamma rays. Some of the kinetic aspects of various systems are presented, and a partial physical evaluation of several of the graft copolymers formed is given.

(5330)

STUDIES ON GRAFT COPOLYMERS DERIVED BY IONIZING RADIATION. D.S. Ballantine, D.J. Metz, Althea Glines, W.K.W. Chen,* and R.B. Mesrobian.* Presented at Natl. Colloid Symposium, Univ. of Wisconsin, June 1956.

Studies are presented on the preparation of graft copolymers by the gamma-ray irradiation of various polymer-monomer combinations. The following graft copolymers have been prepared and evaluated for specific applications: 1) vinyl carbazole grafted to polyethylene to produce a higher temperature dielectric material; 2) styrene grafted to polyethylene and sulfonated to produce a cation exchange membrane of high mechanical strength, low resistivity and high permeaselectivity; 3) styrene surface-grafted to polytetrafluoroethylene for modification of adhesive properties; 4) acrylonitrile grafted to polydimethylsiloxane to increase solvent resistance of the latter.

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(5330)

IRRADIATION OF PLASTICS. D.S. Ballantine. SPE Journal, July (1956).

For several years an increasing interest has been developing in the effect of radiation on the properties of organic plastic materials. A number of papers and review articles have described in detail the changes in physical and mechanical properties which occur when polymeric materials are subjected to intense radiation dosages. This information is of great value to those interested in tensile strength, Rockwell hardness, elongation changes, and other physical properties of a particular plastic. In a number of cases, however, conflicting data have been derived from experiments conducted at different laboratories, and areas of confusion exist. There has been little attempt to delineate the underlying reactions which occur, or their relationship to the changes

observed. It is the object of this review paper to depict the mechanisms of the chemical reactions resulting from irradiation, to show how these reactions can be modified, and to summarize the significant results obtained to date.

(4107.1)

RESONANCE CAPTURE OF NEUTRONS IN A SLAB LATTICE. N.R. Corngold. Presented at APS Meeting, Washington, D.C., April 1956.

An examination has been made of the slowing down of neutrons in a lattice consisting of alternate slabs of non-capturing moderator and non-moderating fuel whose cross sections vary arbitrarily with energy. The Boltzmann equation is transformed to an integral equation into which appropriate boundary conditions are incorporated. Expansion of the flux functions in terms of orthogonal polynomials in space and angle coordinates yields an infinite set of coupled integral equations in energy. In the simplest approximation, and for a hydrogen moderator, these equations are easily integrated to give an expression for the resonance escape probability identical with the one recently derived, from quite different considerations, by J. Chernick (Intern. Conf. Peaceful Uses Atomic Energy, Geneva, 1955, 8/P/603). It is shown that higher order terms in these equations should contribute little to neutron absorption in those capture resonances that contribute most to the integrated capture probability. Thus, while the simplest approximation is not a good one for determining flux distributions, it will be quite good for determining resonance escape probabilities. Numerical results will be given.

(4107.1)

NEUTRON FLUX IN REGIONS WHERE THE CROSS SECTIONS ARE SPACE DEPENDENT. K.T. Spinney. Presented at Am. Nuclear Soc. Meeting, Chicago, June 1956.

The operating conditions of some of the newer reactors are such that the nuclear characteristics of the core may have a strong spatial dependence. The problem of neutron transport in these circumstances is examined with special reference to the validity of neutron diffusion theory. An approximate diffusion equation is derived from the infinite-medium integral equation by means of a Taylor expansion of the space-dependent variables. A direct check on this diffusion type of equation is made by comparing its solution in a special case with the solution of the exact transport equation obtained by Carlson's S_n method. The results indicate that the diffusion equation may be used with confidence (2 percent error in critical size, 10 percent in flux distribution) provided that, in addition to the usual condition that c , the number of secondaries per collision, is close to unity, the fractional rate of change of the cross sections over distances of the order of $1/\kappa$ is small ($\lesssim 0.25$). (κ is the Laplacian).

When c is not close to unity, approximate solutions to the transport equation of the form $e^{\int p dx}$ are obtained by a method of the WKB type, and it is shown that $p(x)$ is given by the formula

$$\frac{p(x)}{\beta(x)} = \tan^{-1} \frac{p(x)}{a(x)},$$

analogous to that of modified diffusion theory.

(4107.1)

THE VARIATION OF α OF ${}_{92}\text{U}^{235}$ WITH ENERGY IN THE INTERMEDIATE-ENERGY RANGE. Sophie Oleksa. Submitted to J. Nuclear Energy.

Recent experiments have made possible a new evaluation of resonance parameters for some of the low-energy levels of ${}_{92}\text{U}^{235}$. The data permit a numerical calculation of the variation of α of ${}_{92}\text{U}^{235}$ with energy in the range 100 to 10,000 ev in accordance with a method proposed by Wigner. Examination of the effects of fitting the experimental

data with several different distributions gives the following results: 1) The variation of α (U^{235}) with energy is a slow one regardless of which of several distributions is assumed to hold for the fission and scattering widths. 2) The values of α obtained by means of Wigner's theory are in good agreement with results of the KAPL integral experiments. 3) The calculated values of $\bar{\sigma}(n,f)$ agree reasonably well with the experimental values. 4) The theory can be applied with confidence to fissionable materials other than U^{235} for which comparable information about low-energy resonances is available.

(4107.1)

A FORGOTTEN MAGNETO-OPTICAL EFFECT. J.R. Lamarsh. Am. J. Phys., in press.

An interesting magneto-optical effect discovered at the close of the last century has gone unnoticed. The experimental evidence for the phenomenon is reviewed and a qualitative explanation is presented. New experiments will be required to obtain a complete understanding of the effect, and such an undertaking is strongly urged.

(†)*

COMPUTATION OF REACTOR TWO-GROUP EQUATIONS ON THE UNIVAC PUNCH CARD COMPUTER.* J.R. Lamarsh and S.S. Rideout. Nucleonics, in press.

Repeated computations of the reactor two-group equations are frequently required in designing thermal reactors. Methods are briefly discussed by which these calculations can be performed on a small and inexpensive electronic computer, the Remington Rand UNIVAC Punch Card Computer. These methods should prove useful for smaller organizations which do not have access to large-scale computing facilities.

*This article is a shortened version of BNL 378 (T-76).

(4640)

ECONOMIC FUTURE OF FISSION PRODUCTS FOR RADIATION POWER. B. Manowitz and D.M. Richman. Nucleonics 14, No. 6, 98 (1956).

An attempt is made to provide a market analysis, a growth pattern for industrial use of radiation, and an appraisal of the expected competition between fission products and other sources of radiation power. From an evaluation of these factors it appears that the recovery of fission products can be a profitable venture for those in the fuel recovery business.

STATEMENT MADE ON MAY 28, 1956, AT HEARINGS BEFORE THE JOINT COMMITTEE ON ATOMIC ENERGY ON PROPOSED LEGISLATION FOR ACCELERATING CIVILIAN REACTOR PROGRAM. (S. 2725 and HR 10805; Government Printing Office No. 78727). J.R. Lamarsh.

Early in an atomic war the major population, communication, and transportation centers of the United States would be destroyed. As a result, the survival of the nation would depend upon the viability of the intact areas. These regions would require, among other things, large amounts of electrical power to meet this unprecedented responsibility. However, stagnation of the transportation system would seriously curtail delivery of the enormous tonnages of fossil fuels required by conventional power plants located in these areas. Key secondary regions would find themselves without power at precisely the time when power was in most critical demand.

Since nuclear power plants require essentially no fuel transportation, areas supplied by power from such installations would suffer no interruption in power production. Therefore, from the standpoint of national defense, it is incumbent upon the federal government to support the development of nuclear power in certain key areas.

*For explanation of this symbol, see Foreword.

INSTRUMENTATION AND HEALTH PHYSICS DEPARTMENT

Instrumentation Division

(1381*
under 5000
Program)

Computers

Construction has started on a copy of Maniac II, a digital computer now being built at Los Alamos. This computer is of the type developed at the Institute for Advanced Study and has a 12,000-word electrostatic memory. Several members of the group have visited Los Alamos to collect information. The memory tubes and some other components are on order and construction of racks and chassis has started.

An analogue computer was purchased jointly with the Medical Department, and a coefficient panel, a servo multiplier, and a curve tracker were built for use with it. With this machine a start has been made on analyzing ionic diffusion between cells in tissue. Work is being done for the Biology Department on a problem concerning the effect of insulin. The Cosmotron group has also used the computer. (R. Spinrad and R. Sugarman)

Preset Timers

(†)**

A 4-channel digital delay generator has been designed to provide preset time signals for Cosmotron experiments. The Cosmotron is timed from a master oscillator and set of scaling circuits, which put out a train of 1-kc clock pulses, starting at injection and lasting for 2 sec. The preset timer contains three glow-tube decade counters and a scale of 2. Four sets of switches and mixing circuits are used to provide four independent preset time signals, adjustable in 0.001-sec steps. The circuits reset automatically whenever the clock pulses stop. (W. Higinbotham and S. Rankowitz)

Densitometer

A recording densitometer has been built to study the time change of density in blood samples. Light from a lamp source is split into two beams and chopped by a rotating shutter at 60 cycles. One beam passes through the sample and the other through a reference wedge. Light from the two paths is sensed by a photomultiplier, amplifier, and servo. The servo drives the wedge to balance the light in the two beams, and also activates the recorder pen. Full scale on the recorder (Varian, Model G-10) covers the range 75 to 100 percent transmission. Accuracy is about 0.1 percent transmission. (R. Spinrad)

Velocity Selector

(†)

The neutron time-of-flight spectrometer circuits described in the last quarterly report were installed to operate with the fast chopper at the reactor. After several minor bugs were corrected, the instrument was put in service on a routine basis.

*For explanation of these numbers, see Foreword.

**For explanation of this symbol, see Foreword.

Figure 1

Kicksorters

A second quartz delay line, 100-channel kicksorter has been completed. Several control chassis have been built for use with the multichannel analyzers containing a 0.1- μ sec coincidence circuit, one or two single-channel pulse height selectors, and a 2- μ sec multiple coincidence-anticoincidence circuit. The input circuit of the 100-channel, R.I.D.L., core kicksorter was modified to work with a high singles input rate when used with the control chassis to analyze a selected fraction of the input pulses. (R.L. Chase)

Low-Background Counters

(†)

A system for low-level counting has been set up for the Health Physics Division, primarily for use in studies of fallout. The system consists of three low-background thin-window Geiger-Muller counters, surrounded by a ring of 11 GM tubes. A 1-in.-thick mercury shield is placed between the counters and the anticoincidence ring, and the assembly is enclosed in a 9-in. iron shield. The counters have 1/4-mil windows of aluminized Mylar and are operated at atmospheric pressure with Q-gas.

Three 1-in.-diameter samples can be measured simultaneously, at background levels of about 0.6 counts/min.

Miscellaneous

A programming unit was built to connect two shaft position digitizers to a Remington-Rand card punch. The digitizers are attached to a microscope for recording coordinates of cloud-chamber tracks.

A number of instruments were purchased and various detectors and circuits were built for the BNL Nuclear Institute, initiated this summer. Lectures on instrumentation and an experiment in scintillation spectrometry were prepared.

Health Physics Division

Cosmotron Safety

(†)

Extensive measurements of radiation levels encountered during external beam operation were made after completion of the dike constructed to terminate the 3-Bev proton beam. Measurements were made with no target in the external beam at a large number of locations in the Cosmotron building, test shack, back yard, and dike areas, in the region of AGS construction, and at outlying points in the direction of the beam. Some of the measurements are recorded in Figure 1. None of those shown were actually in the beam.

Levels at a few selected points were obtained with 1-1/2-, 3-, 4-1/2-, and 6-in.-thick lead targets covering the entire beam at the focus located just outside the Cosmotron building. A 3-in.-thick lead target was found to result in a maximum of scattered radiation, and levels at many points were established for this condition. The action of the lead target increased exposure levels in the test shack by less than a factor of 2. Short runs were carried out at the highest available intensity (about 4×10^{10} protons/pulse internal beam) to establish levels at outlying points; the highest values obtained were in the range of 1 to 5 mrem/hr. The effect of helium bags enclosing most of the beam between the Cosmotron shield and the test shack was evaluated. The following tentative conclusions were reached for the current type of external beam operation:

1. The new dike is effective in reducing levels in regions beyond the immediate Cosmotron area to acceptable values.
2. The point where the beam hits the dike is a relatively weak source of back-scattered radiation and has no appreciable effect on levels in the test shack.
3. For full-intensity external beam operations, levels in the 18-in. cyclotron area are too high for personnel to work safely, except for a limited period of time. Levels in the electron analogue area are tolerable.
4. The use of targets in the external beam will increase levels in all areas, but not to the extent that had been expected.
5. The use of helium bags results in only a minor reduction in radiation levels.

Evening health physics coverage was started at the Cosmotron because of the increased tempo of operations and the extra hazards resulting from frequent use of the external beam. Exposures to the operations staff are becoming a problem, and this factor is now being considered in allocating machine time to various experimental groups.

Levels in the control room averaged 11.2, 13.6, and 18.5 mrep per shift-week for the day, evening, and night shifts respectively. For certain conditions of operation, control-room levels of the order of 100 mrem/hr (with an rbe of 10) are experienced,

but operation at such high levels is infrequent. The highest control-room total for a single week was 46 mrep. Average individual exposures indicated by the NTA film dosimeters were less than 50 percent of the maximum permissible value in all cases.

A small thimble chamber mounted on a vibrating reed electrometer by means of a 14-in.-long stem has been constructed for use as a beam monitor at the Cosmotron. Response from the stem and the electrometer has been shown to be small compared with that from the chamber. The inside of the chamber is 5/16 in. in diameter and 5/16 in. long. It is constructed of 1/32-in. bakelite and is mounted directly on a coaxial cable whose center wire, covered with a sheath of pencil lead, projects to form the central electrode of the chamber. A preliminary current-voltage curve has been obtained with the chamber in the external beam at 1.6×10^{10} protons per pulse (internal), and the chamber appears to be nearly saturated at 300-v collecting potential. A few measurements have been made in the beam about 15 ft from the focus. Values in the range of 1.5 to 2.0 rep per pulse were obtained.

A diffusion cloud chamber for health physics use at the Cosmotron has been obtained from the BNL cloud-chamber group. It will be used to study the distribution of energy among tracks of various densities in regions frequented by the Cosmotron staff. The final objective is to compute an effective relative biological effectiveness ratio. If the technique proves to be successful, an attempt will be made to construct a cloud chamber with approximately tissue-equivalent walls. (M. Beebe, J. Handloser)

Fallout Studies

(6560)

Radioactivity in rainfall is the subject of an extensive program of measurements which has been started in order to study the time sequence of arrival and the extent of contamination of various surfaces. The degree of decontamination that can be effected by flushing these surfaces with a hose is also being tested.

Hourly or half-hourly samples of precipitation are collected by an apparatus that changes containers automatically. The samples are all being assayed for gross radioactivity and, when the volume obtained permits, most samples are being analyzed for radioactive zirconium, molybdenum, iodine, and strontium. A low-level counting apparatus has been set up which uses flow counters of special design, and has a background of about 0.5 counts/min. Decay curves are being obtained for samples with sufficient activity. The activity deposited on a number of surfaces commonly used for building or road construction is measured with a flow-counter probe having a thin window so that beta particles are counted at high efficiency.

The data-collecting phase of the project has just started and no detailed results are yet available. Activity is found in all rain samples; some contain considerably larger amounts, presumably as a result of recent weapons tests. Surface contamination levels have been very low but appear to vary considerably from material to material, depending on the surface texture.

Fallout levels were measured routinely on a daily basis by means of another collector with an ordinary flow counter as in the past. For the current quarter the average rate was 2,480 d/m/m²/day as compared with 2,800 d/m/m²/day for the previous quarter. Daily values varied from below our limit of detectability to 19,000 d/m/m²/day. (J. Weiss, M. Weiss)

Miscellaneous Projects

(†)

The BNL personnel monitoring records for individuals currently using film dosimeters have been standardized and the task of transferring the data to punch cards is nearing completion. (F. Cowan, R. Roth)

A survey article is being prepared summarizing and evaluating existing data on W, the energy per ion pair released during ionization of various gases by radiation. (J. Weiss)

Area radiation levels to be anticipated from reloading of the BNL pile were estimated. An increase at the ground by as much as a factor of 5, compared with present levels, was predicted. Xenon or the active deposits of xenon decay are not expected to constitute a significant problem. (F. Cowan)

Various floor surfaces have been tested for degree of decontamination by BNL janitors' cleaning methods to help in specifying floor materials for the new medical center and for a building at the waste area. Vinyl paint on smooth concrete appeared to be best in this respect. Asphalt and rubber tiles were fairly good except for the cracks. (L. Gemmell)

The response of various fast neutron survey meters used at Brookhaven is being studied as a function of energy by means of the Van de Graaff generator. Some rough data have been collected, but improved techniques are required before definitive results can be obtained. (J. Handloser)

Publications

Ionization Chamber Survey Instrument, W.A. Higinbotham and B.S. Pollock, Submitted to Rev. Sci. Instr.

Amplitude Stabilization of Oscillators by Use of Non-Linear Resistors, M. Graham, Transactions of Symposium on Non-Linear Circuit Analysis at Brooklyn Polytechnic Institute, in press.

The Energy Required to Produce One Ion Pair for Several Noble Gases. II, J. Weiss and W. Bernstein, Phys. Rev., Sept. 1956, in press.

100-Channel Quartz Line Pulse Height Analyzer, R.L. Chase, BNL 401 (I-14), May 1956.

BIOLOGY DEPARTMENT

During the quarter no new members were added to the scientific staff. The following abstracts summarize work submitted for journal publication or presentation at scientific meetings by members of the Biology Department.

(6130)*

ENDOCRINE INFLUENCES UPON THE UPTAKE OF COLLOIDAL THORIUM BY THE RETICULO-ENDOTHELIAL SYSTEM. S.M. Reichard,* A. Edelmann,** and A.S. Gordon.† Submitted to J. Lab. Clin. Med.

The influence of the adrenal and hypophysis upon the uptake of colloidal thorium dioxide by splenic and hepatic tissues was determined by both chemical and radiochemical analyses. Adrenalectomy resulted in a decreased uptake of thorium by the spleen, but the administration of cortisone prevented this action. However, neither adrenalectomy nor replacement treatment with cortisone affected the accumulation of thorium in the liver. Hypophysectomy, on the other hand, increased the thorium concentration in both spleen and liver. The administration of ACTH, OH, hydroxycorticosterone, and a combination of OH and hydroxycorticosterone partially prevented this increase in the liver, but these hormones had no effect upon the uptake of thorium by the spleen of the hypophysectomized rat. The relation of the endocrine system to phagocytosis is discussed.

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(6130)

EFFECT OF 500-r WHOLE-BODY IRRADIATION ON THE CELLULAR COMPOSITION OF THE PERITONEAL FLUID FOLLOWING AN INTRAPERITONEAL INJECTION OF ANTIGEN IN MICE. R.S. Speirs, with the technical assistance of V. Jansen and E.E. Speirs. Submitted to J. Immunol.

A study was made of the effect of 500-r whole-body irradiation on the cellular composition of peritoneal fluid prior to and following an intraperitoneal injection of fluid tetanus toxoid. The following observations were made: 1) Irradiation given prior to antigen injection greatly reduced the number of eosinophil and mononuclear cells in the peritoneal fluid and prevented the increase of these cells in response to the antigen in both immunized and non-immunized mice. The inhibitory effect was marked for 14 days and was still evident on the 42nd day after irradiation. 2) Irradiation given at various times after the antigen injection also reduced the concentration of mononuclear cells in the peritoneal fluid and consistently inhibited the mononuclear response to the antigen injection in both immunized and non-immunized mice. 3) Irradiation given after the antigen injection varied in its effect on the concentration of eosinophil cells according to the immunity of the animal to the toxoid and the time of irradiation relative to injection. In non-immunized animals irradiation had an inhibitory effect on the number of eosinophils. In immunized animals, irradiation 24 and 72 hr after the challenging injection produced concentrations of eosinophils significantly higher than those observed in animals which were challenged but not irradiated. This stimulating effect of irradiation was observed on the 4th day after the challenging injection, but not on the 7th day.

*For explanation of these numbers, see Foreword

The relation of mononuclear and eosinophil cells to immune responses is discussed. No correlation was noted between the effects of irradiation on the mononuclear cell response and the ability of the animal to produce antitoxins. On the other hand there did appear to be a correlation between the effects of irradiation on the eosinophil response and on the ability of the mice to produce antitoxins. It is suggested that eosinophils are part of the antibody-forming mechanism and may form the enzymatic template which is phagocytized and utilized by the mononuclear cells to form antibodies.

(6330)

RADIATION AND IRIS BREEDING. C.F. Konzak and L.F. Randolph.* Submitted to Bull. Am. Iris Soc.

The possible usefulness of radiation as a tool for the breeding of Iris varieties is discussed in relation to known genetic effects of radiations on horticultural and other plants. The results of exploratory experiments indicate that genetic effects may be induced in tetraploid as well as diploid Iris varieties, although no reproducible mutant sectors were obtained, probably because of the small populations studied. It seems likely that certain practical applications of radiation to the breeding of Iris will be found to be economically feasible. Because of the meager data available from experiments with Iris, however, more extensive research is recommended to establish the basis and conditions for practical use.

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(6230)

DOMINANT LETHAL AND TRANSLOCATION DAMAGE IN THE IMMATURE GERM CELLS OF "*DROSOPHILA VIRILIS*" FROM FAST NEUTRONS. Mary L. Alexander.* To be presented at Am. Inst. Biol. Sci. Meeting, Storrs, Conn., August 1956.

The postmeiotic germ cells of *Drosophila virilis* show an increase in translocation damage which follows a "one-hit" curve and increases in proportion to the increase in the dose of fast neutrons. The damage in the more mature cells (A and B) was 2.47 percent translocations at the lowest dose (estimated at 65 rep) and increased to 5.95 percent when the dose was doubled (130 rep) and 13.78 percent for 260 rep. The most sensitive cells recovered were from mating period D; these gave values of 6.03 percent translocations for the lowest dose, 8.29 percent for the second, and 20.00 percent for the highest. The cells from the intermediate period (C) gave values between those for the other two types. The most sensitive cells showed 2.4 times more damage than the less sensitive cells of period A and B at the 65 rep dose level. No translocations were recovered from the premeiotic cells (periods F, G, H).

The dominant lethal damage was measured throughout the cycle in both pre- and postmeiotic cells; in the latter, its highest peak coincided with the high point of translocation damage and was increased about 1.5 to 2 times in the most sensitive cells at the 65 rep dose level. The damage in premeiotic cells dropped to a value of 14 to 17 percent as compared to 40 percent for the most sensitive cells recovered from mating periods D and E.

Small egg samples were checked for the presence of sperm in some mating periods in order to distinguish between cell degeneration, expressed as an absence of mature sperm, and genetic lethality. The fact that none of the eggs checked in period G contained sperm shows the absence of available sperm in this period. Neither the previous period (F) nor the following period (H) showed any indication of this type of damage.

*Summer visitor (1955) from The Genetics Foundation, University of Texas, Austin, Tex.

(6230)

RADIATION-INDUCED AGING IN MICE. H.J. Curtis. To be presented at 5th Intern. Conf. on Radiobiology, Stockholm, August 1956.

Mice that recover from an LD₅₀ dose of x-rays given when they are about 8 weeks old are found to die on the average at about 12 months of age, whereas the controls live about 18 months. Death apparently results from the same causes in both cases. The irradiated mice lose weight at the time of irradiation but soon start to gain again; however, they never reach the weight of the control mice. In order to determine whether x-rays constitute a unique stress with reference to the aging phenomenon, young mice were subjected to massive doses of typhoid toxin or nitrogen mustard. They were more acutely ill than the animals receiving x-rays but soon gained weight to equal that of the controls and lived as long as the controls. Mice subjected to x-rays when young are not as able to withstand a second stress when they are 12 months old as are the controls. The stresses used were a second dose of x-rays, or a large dose of typhoid toxin. Thus x-rays increase the normal rate of aging and differ in this respect from other forms of stress. The most attractive hypothesis advanced to account for this phenomenon is that aging, either natural or radiation-induced, is due primarily to a deficient capillary circulation. Attempts have been made to demonstrate this hypothesis quantitatively by measuring the rate of uptake of tracer doses of radioactive iodine, phosphorus, calcium, or xenon. Preliminary results have shown essentially the same rate of uptake in young, old, and x-rayed animals. It is difficult to judge the accuracy of this method; the conclusion from these preliminary experiments seems to be that the methods developed to date are not accurate enough to detect any differences that may exist.

(6130)

THE INTRAOCULAR LESIONS OF CANINE DISTEMPER. K.V. Jubb,* L.Z. Saunders, and Helen V. Coates.** Submitted to J. Comp. Pathol. Therap.

In canine distemper infection of dogs, intraocular lesions may be present concurrently with or in the absence of brain lesions. If the brain is involved, there may be retrograde degeneration of the retinal ganglion cells via the optic nerve. The lesions found were: degeneration of retinal ganglion cells, edema of the retina, perivascular cuffing of retinal blood vessels, intranuclear eosinophilic inclusion bodies in retinal and optic nerve glial cells, swelling and proliferation of the retinal pigment epithelium, local or widespread atrophy of the layer of rods and cones, atrophy of all the retinal elements with loss of layer organization, focal gliosis, and invasion of the atrophic retina by black pigment. Some of these lesions resembled those reported in the eyes of other animals with natural or experimental viral infections.

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**N.Y. State Veterinary College, Ithaca, N.Y.

(6130)

INTERMEDIATES OF THE PENTOSE PHOSPHATE PATHWAY AS RESPIRATORY SUBSTRATES.* H. Beevers.** Submitted to J. Plant Physiol.

It has been established that D-xylose and D-ribose can be utilized as respiratory substrates by a variety of plant tissues. One of the most active was the corn coleoptile; use of this material in further experiments showed that sedoheptulose and gluconate are also respired. Each of the substrates gave rise to alcohol and CO₂ under nitrogen, although the utilization of gluconate, in contrast to that of the pentoses and sedoheptulose, was markedly reduced under these conditions.

C¹⁴ appeared both in the alcohol and in the CO₂ produced anaerobically (and aerobically in the presence of arsenite) from ribose-1-C¹⁴ and xylose-1-C¹⁴. In addition, the tracer was found to be characteristically distributed in these products:

roughly 2/3 appeared in the CH_3 of the alcohol and 1/3 in the CO_2 . These findings are interpreted to mean that the pentoses were being metabolized by way of the pentose phosphate cycle.

Experiments with gluconates labeled respectively in the 1, 2 and 6 positions showed that release of C-1 is an early reaction in gluconate utilization. The pattern of labeling in the alcohol and CO_2 produced anaerobically from the three gluconates was also consistent with conversion of gluconate to pentose by loss of C-1 in an oxidative step and subsequent conversion to glucose in the pentose phosphate cycle.

The fact that a plant tissue is capable of respiring gluconate, pentose, and sedoheptulose, which represent intermediates in the breakdown of glucose by the pentose phosphate cycle, is of interest in itself. As evidence for the presence of such a cycle in the tissue, a more incisive finding is that the paths taken by individual carbon atoms of the labeled substrates, as indicated by the distribution in the products of anaerobic respiration, are essentially those predicted from the present knowledge of the reaction sequence.

*Part of this work was performed under AEC Contract No. AT(11-1)-330

**Summer student (1955) from Department of Biological Sciences, Purdue University, Lafayette, Ind (6140)

ASCENDING CHROMATOGRAPHY OF POLYPHOSPHATES. G.G. Berg.* Submitted to Anal. Chem.

Variables involved in the chromatographic analysis of polyphosphates were surveyed in order to extend the technique to larger molecules. An ascending method was developed which yielded reproducible R_f values, was sensitive to 0.2% P, and used standard chemical glassware. The method was applied to a study of one-phase alcoholic solvents three variables (choice of alcohol, amount of water, and pH) were characterized in terms of R_f values of polymers, and rules were derived for matching solvent composition to polymer size. An application of the chromatographic method to an analytical problem was presented, which demonstrated identification of polyphosphates in dilute samples.

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(6330)

THE EFFECT OF CORTISONE ON THE NUMBER OF BLOOD LEUCOCYTES AND PERITONEAL FLUID CELLS OF OXYTETRACYCLINE TREATED MICE. U. Wenck* and R.S. Speirs. Submitted to Acta Haematologica.

A quantitative study was made of the changes in the number of blood and peritoneal fluid cells following a single subcutaneous injection of 2.5 mg cortisone acetate in normal mice and in mice pretreated with oxytetracycline. In the blood, cortisone markedly reduced the number of all leucocytes. The period of suppression varied depending upon the type of cell neutrophils and monocytes recovered in number by the 4th day, eosinophils by the 10th day, and lymphocytes by the 29th day. In the peritoneal fluid, cortisone reduced the number of eosinophils for a period of 2 to 3 weeks. The neutrophils, normally not found in the peritoneal fluid, were observed in very small numbers, the number of mononuclear cells and mast cells was unaffected by the steroid. Pretreatment of the animals for one week with 100 ppm oxytetracycline in drinking water affected neither the normal count of blood and peritoneal fluid cells, nor the degree of suppression of these cells by cortisone. However, the number of granulocytes tended to recover earlier in mice not given the antibiotic. The implication of these findings concerning the action of adrenal cortical hormones on leucocytes is discussed.

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(6230)

THE RELATION OF THE ADRENAL TO PHOSPHORUS METABOLISM OF BONE MARROW. I. Berman, A. Edelmann, and A.S. Gordon. Submitted to Endocrinology.

The effects of adrenalectomy on some aspects of bone marrow phosphorus metabolism in the rat have been studied. The incorporation of P^{32} into RNA (ribonucleic acid) and DNA (desoxyribonucleic acid) was increased in the marrow of the 1-day adrenalectomized rat. Five days after adrenal removal the incorporation of P^{32} into the RNA, DNA and PL (phospholipid) fractions was decreased. At 10 days the decreased specific activity of the DNAP was still evident although the specific activity of RNAP and PLP had increased to control levels. The incorporation of P^{32} into all fractions was restored to normal values by 14 days after adrenal removal. One-half-mg doses of 17-OH corticosterone were most effective in preventing the changes noted in the 5-day adrenalectomized animal. Four-mg doses of this steroid increased the specific activity of DNAP but not of RNAP or PLP. However, decreases in the concentration of phosphorus in the latter two fractions were observed. One-half-ml injections of lipo-adrenal cortex extract also increased the incorporation of P^{32} into the DNA fraction of the marrow. The specific activity time curves of plasma inorganic phosphorus were essentially the same in controls and in 5-day adrenalectomized rats. It is suggested that these alterations in P^{32} incorporation are the result of changes in the morphology and mitotic activity of the bone marrow which are induced by adrenal removal and replacement treatment.

(6330)

EFFECT OF CORTISONE ON THE CELLULAR RESPONSE DURING ALLERGIC INFLAMMATION. RELATION OF EOSINOPHILS TO IMMUNITY. R.S. Speirs and U. Wenck. Submitted to Acta Haematologica.

The effect of cortisone on the cellular response to an intraperitoneal injection of pollen into pollen-sensitized mice was studied. The following effects were noted: single or double subcutaneous injections of 2.5 mg cortisone acetate produced a prolonged decrease in the number of blood lymphocytes and a temporary decrease in monocytes. The increase in number of mononuclear cells at the site of the challenging antigen injection was completely inhibited. The number of eosinophils was decreased in both the blood and the peritoneal fluid following the cortisone injection. The local accumulation of eosinophils at the site of the challenging injection was markedly reduced in the animals receiving 2.5 mg cortisone, and completely inhibited in the mice receiving 5.0 mg. The number of mast cells in the peritoneal fluid was not significantly changed following the injection of cortisone or challenging antigen. The significance of these findings was discussed. It was pointed out that toxic antigen, repeated biopsies, injections, or other stressing actions would activate the adrenal cortex and lead to a marked change in the local cellular reactions. This seemed a possible explanation for the numerous reports indicating that eosinophils are not consistently found in allergic inflammation. The relation of the eosinophil to immune processes was discussed and it was noted that there appears to be a close correlation between accumulation of eosinophils and antibody production.

(6330)

THE EFFECT OF IONIZING RADIATION ON THE CARNATION, "DIANTHUS CARYOPHYLLUS." II. THE EFFECT OF X-RAYS ON FLOWER COLOR. Y. Sagawa and G.A.L. Mehlquist.* To be presented at Am. Inst. Biol. Sci. Meeting, Storrs, Conn., August 1956.

This experiment is one of a series whose purpose is to study means of increasing the efficiency of mutagenesis by ionizing radiations. The effect of x-rays on flower color was studied with three carnation clones: William (red) Sim, and two of its spontaneously-derived color variants, Pink Sim and White Sim. The carnation (Dianthus

caryophyllus) was chosen as the test organism because the inheritance of its flower color had been previously established and the breeding behavior of the three clones used was known. Breeding tests have shown Pink Sim and White Sim to be periclinal chimeras with the mutant condition in the outer layers of cells only, not deep enough to affect the formation of gametes.

Rooted cuttings of the three clones were irradiated with a single x-ray dose of either 2500 r or 5000 r. Flower color was recorded when the plants came into bloom some eight months later. An extremely high rate of change (47 to 91 percent) from pink to red and from white to red was observed. A much lower rate of change (0 to 4 percent) from red to white or red to pink was noted. This finding suggested that the change to red flower color was not due to genetic change but was related to the chimeric nature of Pink Sim and White Sim. An anatomical study of the stem apex at various intervals after irradiation revealed that the radiation caused selective destruction of its outer layers, followed by regeneration of a new apex from the more deep-seated cells. The newly reconstituted apex was thus non-chimeric and was capable of producing red flowers because of its endogenous origin.

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(6130)

DISTRIBUTION OF RENAL ARTERIAL AND PORTAL FLUIDS TO PROXIMAL TUBULES IN DOUBLY-PERFUSED FROG KIDNEYS. R.E. Swanson. To be presented at Am. Physiol. Soc. Meeting, Rochester, N.Y., September 1956.

PAH (p-aminohippurate) was perfused via the renal arterial and/or renal portal systems to the frog kidney in concentrations sufficient to insure a maximal rate of tubular secretion (Tm). For a given kidney, PAH Tm usually remained fairly stable over 6 to 8 hours of perfusion when PAH was perfused via both the arterial and portal routes or by the portal route only. The purpose of the experiments was to ascertain the physiologic distribution of arterial and portal fluids to the PAH-secreting portion of the renal tubule. A change in the PAH Tm was assumed to result from a change in the number of nephrons being perfused with PAH. When the PAH was introduced to the tubules by either the arterial or the portal route, the Tm was found to be reduced to about 50 percent of the value obtained when the PAH was perfused via both systems simultaneously. These results seem to indicate that there are areas of the proximal tubules perfused largely by arterial fluid but not by portal fluid, and vice versa, and that there is relatively little overlap in the two areas. That portion of the PAH-secreting part of the tubule accessible to the portal system seems quite discrete, since varying the percent of portal perfusion (with a constant arterial perfusion rate) had little effect on the Tm.

(6230)

ABERRANT PATTERNS OF SOME PHOTOSYNTHETIC ENZYMES. R.C. Fuller and M. Gibbs. J. Am. Soc. Plant Physiol., Suppl., in press.

The hypothesis has been advanced that some enzymes concerned with the fixation and reduction of CO₂ by plants in the light are unique to the photosynthetic process. These are the carboxylating enzyme and the TPN-dependent triosephosphate dehydrogenase. A survey of the following autotrophic and heterotrophic organisms has been made for these two enzymes and the DPN-dependent triosephosphate dehydrogenase. Some organisms which have all three enzymes are: pea leaves, green barley leaves, Chlorella, Chlamydomonas, Euglena, Rhodospirillum, spinach chloroplasts and Romeria. Those which contain only the DPN-dependent triosephosphate dehydrogenase are: pea roots, Tetrahymena, streptomycin-bleached Euglena, dark-grown Euglena and glucose-grown E. coli. Organisms which do not conform to the above patterns and therefore are aberrant for any established photosynthetic or heterotrophic pattern are:

a genetic albino barley mutant which contains both triosephosphate dehydrogenases but not the carboxylating enzyme; Astasia (a naturally colorless Euglena), and xylose-plus-CO₂-grown E. coli, which contain the carboxylating enzyme but not the TPN-dependent triosephosphate dehydrogenase. It is therefore suggested that these enzymes are not unique to the carbon reduction process of photosynthesis.

(6330)

THE EFFECT OF IRRADIATION ON REPRODUCTION BY THE HETEROGENETIC GENERATION OF "STRONGYLOIDES PAPILLOSUS" (WEDL, 1856) RANSOM, 1911.* F.F. Katz.** Submitted to J. Parasitol., Suppl.

Attempts were made, without success, to induce successive free-living generations in Strongyloides papillosus, in which this phenomenon apparently does not normally occur, by irradiation of the sperm and/or ova. Theoretically, such gynogenetic and/or androgenetic induction should be possible in view of the triploidy which has been observed in this worm (Chang and Graham, personal communication). Although x-rays were used, the major work involved cobalt-60 gamma irradiation. The nematodes were cultured in vitro under non-sterile conditions; the best cultures were obtained in open depression slides with a nutrient agar-fecal extract medium diluted to one-half with distilled water and adjusted to pH 7.

Extensive data were accumulated concerning immediate irradiation effects. Results have been analyzed on the basis of the number of larvae per bisexual pair or gravid female, hatching, survival, and lethal and dominant lethal effects. Fewer offspring were produced in bisexual cultures containing irradiated males of the fourth and fifth stages than in bisexual cultures of irradiated third or fourth stage females. Increased doses of irradiation decreased the percentage of eggs hatching and of surviving larvae. Cleavage rate and embryogenesis were delayed by irradiation. Spermatozoa were still active in uteri 5 hr after 20 kr exposure. The production of lethal and dominant lethal effects increased with increased dosage; at 20 kr in gravid females and 40 kr in bisexuals 100 percent killing effects occurred.

*Part of a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Pennsylvania, Philadelphia, Pa.

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(6130)

THE INCORPORATION OF P³² INTO LIVER PHOSPHOLIPIDS AND RNA MONONUCLEOTIDES OF IRRADIATED AND NONIRRADIATED MICE.* F.G. Sherman and A.B. Almeida.** To be presented at 5th Intern. Conf. on Radiobiology, Stockholm, August 1956.

Male mice weighing 18 to 20 g were irradiated with 600 r of filtered 200-kv x-rays. Immediately after irradiation the animals were injected intrapleurally with a buffered physiological saline solution containing 20 microcuries of P³² as inorganic orthophosphate. The livers were removed at intervals 30 to 360 min after injection and frozen immediately in an acetone - dry ice mixture. Specific activities were determined on the following fractions: plasma inorganic phosphate, liver inorganic phosphate, liver total acid-soluble phosphate, liver RNA mononucleotide phosphate, DNA, lecithin, cephalin, and sphingomyelin. The phospholipids were separated chromatographically on magnesium oxide. RNA mononucleotides were separated by paper electrophoresis.

The relative specific activity of the mononucleotides of liver RNA was in each instance higher in irradiated than in nonirradiated animals. Three hr after injection of P³²O₄, the relative specific activity of RNA mononucleotides from nonirradiated mice reached a value which remained approximately the same until 6 hr after injection.

The relative specific activity of the RNA mononucleotides from irradiated animals increased throughout the course of the experiment. The relative specific activity of liver DNA was lower in irradiated than in nonirradiated animals.

During the first 3 hr after irradiation more P^{32} $\left(\frac{\text{cts/min}/\mu\text{g phospholipid P}}{\text{cts/min}/\mu\text{g liver inorg. P}} \right)$ was incorporated into the liver phospholipids of irradiated animals than of nonirradiated animals. The activity of phospholipids from irradiated animals returned to control values 6 hr after irradiation. During the first 3 hr after irradiation, the relative specific activity of cephalin was higher than that of lecithin and sphingomyelin in both irradiated and nonirradiated animals. At 6 hr after injection of P^{32} the relative specific activity of lecithin was higher than that of cephalin. The relative specific activity of sphingomyelin remained below that of cephalin and of lecithin throughout the experiment.

*Supported in part by a grant-in-aid to Brown University from the American Cancer Society upon recommendation of the Committee on Growth of the National Research Council.

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(6140)

SINGLE PHOTOTUBE LIQUID SCINTILLATION COUNTING OF C^{14} ; APPLICATION TO AN EASILY ISOLATED DERIVATIVE OF BLOOD GLUCOSE. R. Steele, W. Bernstein,* and C. Bjerknes. Submitted to J. Appl. Physiol.

Conditions for efficient and reproducible liquid scintillation counting of C^{14} with a single phototube are described. The amplifier, scaler, and power supply are the same as those used for the gas-phase proportional counting of $C^{14}O_2$ admixed with P-10 gas (9.1 argon-methane). A compound which will dissolve to the extent of about 10 mg per 25 ml xylene or 4 l xylene-ethanol, which does not absorb light in the blue region, and which does not quench phosphor scintillations, can be assayed for C^{14} by this method with a sensitivity about equivalent to that of the gas-phase counting method which entails combustion of the compound to CO_2 . The counting efficiency in xylene is about 80 percent and in 4 l xylene-ethanol about 70 percent of the C^{14} disintegrations occurring in the sample. The background counting rate is about 90 cts/min. Glucose, isolated as the phenylosazone from a biological fluid, is converted to the glucosotriazole derivative, which is suitable for scintillation counting. The derivative is held in solution with the aid of H_3BO_3 in 25 ml 4 l xylene-ethanol containing 0.24 percent of the phosphor PBD (2-phenyl-5-(4-biphenyl)-1,3,4-oxadiazole). The standard deviation for individual samples in a specific activity determination, including the error in weighing the 10-mg sample of glucosotriazole derivative, is ± 1.7 percent.

*Member of Instrumentation Division.

(6140)

A METHOD FOR CONTINUOUS LOW-DOSE BETA IRRADIATION OF THE RAT PITUITARY. J.F. Gennaro, Jr.* To be presented at Am. Soc. Zool. Meeting, Storrs, Conn., August 1956.

The few studies dealing with local direct irradiation of the pituitary have been restricted to observation of the effects of high doses delivered over short periods of time. Irradiation of the pituitary in this manner seems to result in the production of an animal more or less completely hypophysectomized, depending on the efficacy of the radiation technique and the post-treatment time allowed to elapse.

The manufacture of the fused montmorillonite "macrobead" radiation sources used in the present study has been described by Ginell and Doering (BNL 341 (T-60)). Radioactive beads containing 10 microcuries of strontium-90 - yttrium-90 and similar control beads containing no radioactivity were implanted in the portion of the sphenoid

bone adjacent to the pituitary in young male and female Sprague-Dawley rats. Growth in these animals, as determined by body-weight increase over the 9- to 12-month radiation period, was found to be significantly less in the experimental than in the control groups. Pituitary and adrenal organ weights are lower in the irradiated group, and the 24-hr uptake of ^{131}I in the thyroid glands of the pituitary-irradiated rats was found to be seven times that in the thyroids of the sham-irradiated animals.

These results seem to indicate that continuous local irradiation interferes with the function of the pituitary. It is suggested that the method may permit observation of the extent to which the irradiated gland operates under conditions of continually reduced physiological efficiency.

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(6330)

CROSSING-OVER STUDIES WITH "DROSOPHILA" AND MAIZE. D. Steffensen, Lulu F. Anderson, and S. Kase. To be presented at Genet. Soc. Am. Meeting, Storrs, Conn., August 1956.

Recent studies have indicated that *Tradescantia* chromosomes of cells deprived of calcium had a high rate of spontaneous breakage and an increased sensitivity to x-rays. To test the hypothesis that metal ions function in chromosome stability, nutritional experiments were extended to crossing-over studies.

Female larvae of *Drosophila melanogaster*, heterozygous for garnet (g^2) and cut (ct^6), were raised on food containing: 1) 0.01 M ethylenediaminetetraacetic acid (EDTA or Versene), 2) 0.01 M EDTA plus 0.04 M potassium, and 3) 0.15 M potassium. The most effective treatment, EDTA + K, showed in the progeny a 20 percent increase in crossing-over above controls. When adult females, heterozygous for $y\ ct\ ras\ f$, were fed media with EDTA (0.01 M to 0.08 M) no increase in recombination above controls was detected in their progeny. The frequency of crossing-over, at least in the gametes of *Drosophila* larvae, can be altered chemically. The *Drosophila* evidence does not permit a distinction between any of the following mechanisms of increasing crossing-over: 1) higher chiasmata frequency, 2) more complete pairing, 3) less chromatid interference, or 4) complications due to sister-strand crossing-over.

Maize plants with the genotype I Sh Bz Wx/C sh bz wx were grown in quartz sand with Hoagland's solution containing optimal calcium (250 ppm Ca^{++}) or low calcium (6.25 ppm Ca^{++}). The corn plants used did not grow with less than 6 ppm calcium. Pollen was tested on detasseled plants homozygous for C sh bz wx. A total of 22,109 seeds were examined. Chi square tests between treatments for each of the three regions indicated no significant differences in crossing-over. Pooled data gave recombination values between C-Sh and Sh-Bz almost identical to those reported by Rhoades (Am. Naturalist 86, 105 (1952)). Limitations of nutritional techniques in crossing-over studies are discussed.

(6330)

TUBE NUCLEUS DIVISIONS IN "TRADESCANTIA" POLLEN ASSOCIATED WITH A TRANSLOCATION. Lulu F. Anderson and D. Steffensen. To be presented at Genet. Soc. Am. Meeting, Storrs, Conn., August 1956.

During a series of mineral-deficiency studies on *Tradescantia paludosa* (clone 5 of Sax), a seedling mutant was detected by cytological screening. This plant showed an almost constant rate of 25 percent pollen abortion. Smears of meiosis showed the abortion to be due to the segregation of a translocation which had the typical ring of four at the first meiotic metaphase. On further examination of the pollen, it was ob-

served that the tube nucleus, which normally degenerates, sometimes underwent a complete division. This resulted in pollen with three nuclei, the dark-staining generative and two lighter-staining nuclei of similar size. All stages of division in the tube nucleus have been observed. Although trinucleate cells were always present in pollen samples of the mutant plant, their frequency showed a large variability probably due to environmental factors.

The plant was selfed in order to determine whether the tube nucleus phenomenon was associated with the rearranged chromosomes. If the two were directly related the three types expected would be: 1) the normal, 2) the heterozygous with tube nucleus divisions and abortion, and 3) the homozygous rearranged with tube nucleus divisions and no abortion. Examination of the progeny of the selfing showed conformity to a 1:2:1 ratio by the chi square test of normal, heterozygous, and modified types, respectively. The ability of the tube nucleus to undergo division, therefore, seems to be a result of the chromosome rearrangement.

(6330)

GENETIC EFFECTS OF IONIZING RADIATION ON HIGHER PLANTS. C.F. Konzak. To be presented at Botan. Soc. Am. Meeting, Storrs, Conn., August 1956.

The precise nature of mutational events induced in the cell by radiation is still incompletely understood; nevertheless, radiation has proved to be a valuable tool in genetic research. Classical genetic theory of the linear arrangement of genetic loci on the chromosomes, linkage, and the cytological localization of genes has been confirmed through radiation studies. Induced mutations have increased the knowledge of genes and gene action in higher plants, although the question remains as to whether some changes are identical with those of spontaneous origin. All types of ionizing radiation appear to induce generally similar types of mutational changes; the relative frequency of specific mutant classes may vary. In some plants, such as wheat, Triticum vulgare L, or Arabidopsis thaliana L, rates of mutations (broadly defined and calculated on a plant progeny basis) exceeding 20 percent have been induced. External and internal factors have been shown to modify the frequency of mutations induced by certain radiations. Among these factors, oxygen concentration, freezing, physiological or enzymatic activity, hydration or dehydration greatly influence the observed mutational response to x-rays, but have comparatively less influence on the effects induced by more densely ionizing radiations such as thermal neutrons.

The recent increase in research on agricultural plants has led to fuller recognition of the value of induced mutations in plant breeding. The induction by radiation of agronomic characteristics such as disease resistance, shorter straw, stiffer straw, and earliness in cereals, as well as similarly valuable changes in other plants, has been accomplished by investigators in many parts of the world. Because of this recognized potential, mutation research has become one of the most stimulating and rapidly advancing fields of plant biology.

(6130)

A CHROMATOGRAPHIC STUDY OF HYDROLYSIS IN THE FEULGEN NUCLEAL REACTION. P.S. Woods. To be presented at Am. Inst. Biol. Sci. Meeting, Storrs, Conn., August 1956.

In a study on Feulgen hydrolysis of frozen-dried alcohol-fixed lily anthers, a chromatographic technique was developed to analyse the acid hydrolysate for some of the degradation products of nucleic acid. Hydrolysis was accomplished by 10 percent perchloric acid at 20°C, and a typical hydrolysis time - Feulgen intensity curve was obtained, with optimum hydrolysis occurring at 16 hr. Analysis of hydrolysates revealed that RNA (ribonucleic acid) uracil was quantitatively separated from the DNA (desoxyribonucleic acid) thymine of tissue sections by 1-1/2-hr hydrolysis. Essentially

all free purines were removed from the tissue DNA by the time of optimum hydrolysis. Some DNA was slowly degraded shortly after the onset of hydrolysis; by optimum hydrolysis approximately half the total DNA was lost from the tissue sections. The reliability of the Feulgen method in conjunction with microphotometric measurement of Feulgen-stain to represent amount of DNA per nucleus was discussed in the light of these observations.

MEDICAL DEPARTMENT

Division of Pathology

Follow-up Studies on the Marshallese Exposed to Fallout Radiation

(6220)*

One death has occurred among the Marshallese people who were exposed to fall-out radiation in March 1954. An autopsy was performed at Majuro and tissues were forwarded to Brookhaven. Histologic study revealed left ventricular hypertrophy in an individual with nephrosclerosis. There is no gross radioactivity in the bones. Refined radiochemical studies are under way. (R.A. Conard, E.P. Cronkite, V.P. Bond, J.S. Robertson, and S.W. Lippincott)

Cancerogenic Action of Local Beta and Graded Doses of Whole-Body Irradiation

(6220)

With the experimental design previously described no late skin lesions have developed.

Mammary tumors continue to develop. There is some evidence that these tumors are dependent upon the ovary for continued growth.

A second series of rats was irradiated with graded doses of x-ray: 0, 50, 100, 200, 400, and 600 r. Tumors commenced appearance in the third month; this finding confirms the earlier report. The development appears to be dose-dependent. (E.P. Cronkite, V.P. Bond, C.J. Shellabarger, S.W. Lippincott, and R.A. Conard)

Studies on Distribution of Radiosulfate in Rats

(6120)

When rat platelets were labeled with $S^{35}O_4$, the uptake of $S^{35}O_4$ by the proximal convoluted tubule of the rat kidney in an insoluble macromolecular form was found to be striking, producing clear intraepithelial concentrations on radioautographs. The turnover rate is under study. (E.P. Cronkite and D.E. Paglia)

Dynamics of Production and Destruction of Formed Elements of the Blood and Relation to Blood Coagulation and Hemostasis under Normal and Abnormal Conditions

(6120)

Development of methods for rapid leukophoresis and thrombocytophoresis by establishment of an extravascular shunt and filter system is progressing in an encouraging manner. If this work proves successful, a simplified method will be available for the study of positive and negative feedback systems in control of platelet and white cell production. (E.P. Cronkite)

The Thyroid Effects of Sulfonamide Hypoglycemic Agents

(6120)

N-p-aminobenzenesulfonyl-N'-n-butylurea has been shown to depress I^{131} uptake and to be goitrogenic in rats. However, N-toluenesulfonyl-N'-n-butylurea did not exhibit any goitrogenic effects and failed to depress I^{131} uptake when administered to

*For explanation of these numbers, see Foreword.

rats. The reasons for the difference in the antithyroid effects of these two compounds are the object of further study. (C.J. Shellabarger)

Antigoitrogenic Effects of Thyroxine Analogues

(6120)

The ability of triiodothyronine and the acetic acid analogues of thyroxine and triiodothyronine (triac and tetrac) to prevent the goitrogenic response to propylthiouracil has been tested in rats and fowl. In terms of thyroxine in the rat, the approximate potencies of triiodothyronine, triac, and tetrac were 5, 0.5, and 0.5 respectively. In the White Leghorn cockerel the potencies were 1.0, 0.2, and 0.2 respectively. (C.J. Shellabarger)

Exhibits

Three kinds of exhibits have been made and studied for their effectiveness in regard to: 1) suitability for type of audience to be reached, 2) attractiveness with reference to size, arrangement, and photography, 3) scientific content, 4) educational panel, and 5) final over-all teaching value. The first of these exhibits to be presented was entitled "Thyroid Pathology in Alpha and Beta Radiation" and was demonstrated at the Forty-fifth Annual Meeting of the International Academy of Pathology, April 23-25, at Cincinnati, Ohio. The exhibit consisted of three sets of data in 11 x 14 dye transfer prints in color, together with an explanatory panel. The material included: A) a comparison of the effects of I^{132} and At^{211} on the rat thyroid five days after radiation, B) the production of myxedema in the dog by I^{131} , and C) the effect on the thyroid of I^{131} administration to man (normal, hyperthyroid, and neoplastic thyroids). Suitable autoradiographs of alpha- and beta-particle tracks and of uptake in a neoplasm were also shown. (S.W. Lippincott, C.J. Shellabarger, and C.G. Lewallen)

Division of Microbiology

Preparation and Chemistry of Astatine

(6120)

The previously reported procedures for the preparation of astatine (At^{211}) have been simplified. Bismuth is melted onto the center of a 20-mil sheet of silver, which acts as the support, and milled to a thickness of 5 mils. This thickness of bismuth is adequate to utilize the effective energy range of the α beam, and the rest of the beam is absorbed in the silver backing. The target is assembled with 13 mils of aluminum (1-mil window plus 12-mil sheet) in front of the bismuth to slow the 42-mev beam of the 60-in. Brookhaven cyclotron to 29 mev, the threshold for the α -3n reaction with Bi which gives the undesirable At^{210} . After 3 or more hr of bombardment, the target is disassembled and the astatine distilled from the bismuth in air in a sealed glass tube with a cooled tip at essentially atmospheric pressure and 500 to 550°C for 2 hr. The astatine may be washed from the cooled tip with water or organic solvents.

The improvements appear to be first, distillation under pressure to prevent sublimation of bismuth, and second, the use of a noble metal (silver) backing instead of aluminum, which increases the yield, presumably because formerly aluminum astatide of high thermal stability was formed. (The Berkeley group has recently changed to a gold backing, probably for similar reasons; however, at Brookhaven silver is preferred because of its greater mechanical strength and lower cost). In this way 10 or more millicuries of astatine are readily prepared for chemical studies.

The preparation of astatinated organic compounds is being carried out primarily through their diazonium intermediates. This route has proven practical for the

preparation of a variety of compounds at tracer levels with iodide used as a quasi-carrier. Distribution studies between immiscible solvents indicate that the following compounds have been successfully prepared: phenyl astatide, p-astatobenzoic acid, and p-astatobenzenesulfonic acid and its acid chloride. Use of the last enables astatine to be incorporated into serum albumin, gamma globulin, and fibrinogen without appreciable denaturation of the protein. (W.L. Hughes, E. Smith, and J. Klinenberg*)

Ionizing Radiation Effect Upon Anaphylaxis

(6320)

The enhancing effect of cobalt-60 gamma radiation upon anaphylactic shock in mice has been previously demonstrated. Passive and reversed passive anaphylaxis with homologous antibody, and passive anaphylaxis with heterologous antibody were more severe in 7-day post-irradiated mice. The mechanisms involved in the phenomenon of anaphylaxis in the mouse are not known. Active and passive anaphylaxis is being studied in irradiated mice and guinea pigs in an attempt to determine the mechanisms involved in anaphylactic response in irradiated and nonirradiated animals. (R.D. Stoner)

Isolation from Microorganisms of Enzymes Selective for Glycoproteins

(6120)

The investigation of the action of bacterial culture filtrates on the acid glycoprotein isolated from nephrotic urine is being continued. Preliminary results indicate that bacterial enzymes may be of considerable help in studying the structure of the glycoprotein. Two bacterial species have been found whose culture filtrates appear to act on the glycoprotein in a specific way.

Cl. perfringens filtrates contain an enzyme which specifically removes the "sialic acid" portion of the molecule. At the present time, details of the enzymatic reaction and the consequences to the protein of the loss of this component are being studied. Methods for increasing the activity of the filtrates are being investigated.

Another species of bacteria isolated from soil will grow in a simple salt solution to which the glycoprotein has been added; good growth curves are obtained with increasing amounts of glycoprotein. The glycoprotein which has been acted upon by the growing cells loses its ability to precipitate with specific antiserum. Further studies are being carried out on the culture filtrates from this organism. (R.M. Drew and E.A. Popenoe)

Plasma Lipoprotein Metabolism in Normal Individuals and in Children with the Nephrotic Syndrome

(6320)

A study made in collaboration with Dr. David Cromwell of the Children's Medical Center, Boston, and Dr. J.L. Oncley of the Harvard Medical School, has shown that the hyperlipemia and hypercholesterolemia characteristic of the nephrotic syndrome are due to an elevation of lower density β -lipoproteins, primarily the S_f 10 to 400 class. The concentrations of α -lipoprotein and higher density β -lipoprotein, S_f 3 to 8, are either normal or somewhat decreased.

The peptide moieties of human α - and β -lipoproteins were labeled with ^{131}I , and the metabolism of these proteins was studied in normal children and adults and in children with the nephrotic syndrome. The half-life of α -lipoprotein was about 4 days in normal subjects, but in children with the nephrotic syndrome its catabolism was accelerated.

The metabolism of β -lipoprotein was complex. In normal individuals the lower-density β -lipoproteins were rapidly converted to those of higher density and catabolized

*Summer student (1955) from Johns Hopkins University, Baltimore, Md.

as such; the latter had a half-life of about 3 days. This conversion did not occur in vitro nor was the conversion of a higher-density β -lipoprotein (S_f 3 to 8) to one of lower density (S_f 10 to the chylomicra) observed in either normal or nephrotic individuals. In the nephrotic child, the fractional rate of conversion of lower-density β -lipoproteins (S_f 10 to 400) to those of higher density was greatly decreased; hyperlipemia in these children was attributable, at least in part, to this conversion failure. The catabolism of higher-density β -lipoprotein appeared normal or slightly accelerated in nephrosis, while the low-density β -lipoproteins isolated from nephrotic plasma were converted and catabolized normally in healthy individuals.

It would seem, therefore, that: 1) a system for the unidirectional conversion of low-density β -lipoproteins to those of higher density exists in vivo and is normally operative, 2) there is a partial failure of this conversion system in the nephrotic syndrome, and 3) the metabolism of the lipoproteins explains their plasma concentration in nephrotic children. The hyperlipemia in nephrosis is due in part to decreased conversion of S_f 10 to 100 and in part to an overproduction of this lipoprotein class. (D. Gitlin*)

Plasma Protein-Sparing Effect of Fats and Carbohydrates

(6320)

Groups of litter-mate mice were placed on various synthetic diets. In the diets tested, protein made up 0 to 25 percent of the total calories, and fat and/or carbohydrates accounted for the remainder. The diets were supplemented with appropriate salts and vitamins. Mouse albumin and γ -globulin were labeled with I^{131} and given to the recipient mice intravenously. Use of a Texaco-type counter with a 2-in.-diam. well made it possible to count the radioactivity in the whole mouse without resort to bleeding; whole body counting also eliminated some of the problems associated with intravascular-extravascular mixing and changes in the sizes of the various body plasma protein pools associated with changes in weight.

A diet sufficient in calories but without protein was found to cause a decrease in plasma albumin catabolism as well as a decrease in the synthesis of albumin; the calories were supplied by fat or carbohydrate. A decrease in albumin catabolism was noted also in those mice on a diet markedly deficient in calories but otherwise well balanced; in these instances, however, the fall in catabolism was much less than that seen in the protein-starved mice receiving adequate calories from fat or carbohydrate. A condition resembling caloric starvation was noted in mice made diabetic with alloxan and in baby mice abruptly weaned from their mothers, although they were taking the chow diet. Attempts to induce plasma protein conservation with testosterone or estrone were unsuccessful. Diet had little effect on the metabolism of γ -globulin; this observation is in accord with findings in starvation in humans.

It would seem that the nitrogen-sparing effect of carbohydrate and fat may be due in part to a decreased catabolism of certain proteins. Contrary to expectations, starvation with depletion of carbohydrate and fat stores resulted in a decrease in the catabolism of certain proteins rather than an increase. (D. Gitlin)

Division of Biochemistry

"IN VITRO" METABOLISM OF DL-ALANINE-2- C^{14} AND GLYCINE-2- C^{14} BY "TRICHINELLA SPIRALIS" LARVAE. L.V. Hanks and R.D. Stoner. Proc. Soc. Exptl. Biol. Med. 91, 443 (1956).

Trichinella spiralis larvae incorporated C^{14} when cultured in vitro in a serum-Krebs-Ringer medium or Krebs-Ringer medium containing either DL-alanine-2- C^{14}

*Guest from the Children's Medical Center, Boston, Mass.

or glycine-2-C¹⁴. Carbon-14 analysis of the larvae revealed a progressive uptake of the C¹⁴-labeled amino acids in both types of media through 48 hr of incubation. The larvae incorporated more C¹⁴ activity (cpm) from glycine-2-C¹⁴-labeled media than from DL-alanine-2-C¹⁴-labeled media. Of the total C¹⁴ incorporated by larvae cultured 48 hr in glycine-2-C¹⁴-labeled media, about 70 to 84 percent was precipitable by tungstic acid, and was presumably located chiefly in the proteins. Larvae cultured in the DL-alanine-2-C¹⁴-labeled media incorporated about 32 to 57 percent of their total C¹⁴ content into material precipitable by tungstic acid.

Division of Physiology

Comparison of Radiosensitive Unit Sizes of Acetylcholinesterase Obtained from Different Tissues of a Single Species (6120)

Preparations of pooled whole brains, red blood cells, and plasma, obtained from five Wistar albino rats, were thoroughly lyophilized and exposed to cobalt-60 gamma radiation. From the rates of inactivation of the acetylcholinesterase in each of these tissues, the radiosensitive target sizes were calculated. These were found to be: brain, 100,000; plasma, 150,000; rbc, 325,000. These values, based on gamma-radiation experiments only, are probably high; however, they serve to indicate the relative sizes of the target units. Especially striking is the difference between the rbc and brain specific acetylcholinesterases, which had been considered as enzymatically identical. It is postulated that this marked difference in radiosensitive volume between these two true acetylcholinesterases of the same animal reflects differences in the structures of the proteins in question. (I. Serlin)

Effect of Ionizing Radiations on Mixtures of Acetylcholinesterase and Choline (6120)

Choline, one of the most radiosensitive organic compounds known, is a strong inhibitor of acetylcholinesterase. Mixtures of choline and acetylcholinesterase are being subjected to ionizing radiations to determine whether the enzyme is afforded protection by the presence of its radiosensitive inhibitor. The concentration of tissue or enzyme capable of interfering with the radiation-induced, free-radical decomposition of the choline is being investigated. (I. Serlin)

Studies on the Physiology of Manganese. I (6220)

Work continues with Mn⁵⁶ *in vitro* and *in vivo*. Further data from equilibrium dialysis were collected in order to elucidate metal binding by tissue and blood fractions. Binding of manganese by albumin and total plasma proteins is accounted for largely by the imidazole groups. Tissue binding appears to depend significantly although not exclusively on similar binding sites. Metal association with tissues *in vitro* is far greater than with plasma. This finding is compatible with previously published data collected on humans and intact animals. The partition of the metal is affected by drugs with broad pharmacological action. (D.C. Borg and G.C. Cotzias)

Studies on the Physiology of Manganese. II (6220)

Some early data suggest that in certain metabolic diseased states manganese distributes itself differently than in normal states. The typical distribution picture was found to be markedly altered also when either metabolizable or nonmetabolizable

chelating agents were employed to change the metal's chemical characteristics. This avenue is being vigorously pursued in order to explore the possibility of selective delivery of isotopic radiation to a specific body site. Data are being collected on hospital patients as well as on experimental animals. The list of chelating agents has been enriched by the use of Schiff's bases of pyridoxal with amino acids as metal-binding agents. These are used on the basis of the evidence of Christensen *et al.* (J. Biol. Chem. 220, 265 (1956)), which suggests that amino acid transport into cells depends upon the formation of such complexes. Similarly, blood disappearance of manganese is being followed with various complexing agents.

Experiments have been done which were designed to investigate the various components of the blood-disappearance curves. The early rapid component is being compared to the rapid component presented by $H_2^{18}O$. The slow components are being compared to those of metal complexes of various molecular volumes including protein complexes. It is thus hoped to gain insight into the metal's normal transport mechanisms and into the variations induced by disease and by artificial chelation. (G.C. Cotzias and D.C. Borg)

Studies on the Physiology of Manganese. III

(6220)

In view of the fact that the body turnover of manganese proceeds at two different rates, the intracellular distribution is being investigated as a function of time in mouse liver and brain. The initial observations published for rat liver (L.S. Maynard and G.C. Cotzias, J. Biol. Chem. 214, 489 (1955); G.C. Cotzias and L.S. Maynard, Proc. Intern. Conf. Geneva 12, 444 (1955)) seem to hold essentially true for these two organs of the mouse as well. Furthermore, no evidence of important change in intracellular distribution was elicited in a series of tissue fractionations covering an interval of about two weeks following the initial injection of Mn^{52} . (G.C. Cotzias and H. Hamel)

Role of Carbohydrate and Mineral Metabolism in Control of the Cerebral Excitatory State

(6320)

The marked depression by pyribenzamine (at 10^{-3} M) of the steady-state glucose level in rat cerebral cortical slices incubated *in vitro*, described in the preceding Quarterly Progress Report, has been found to be almost entirely attributable to enhancement of glycolysis, a process which in this tissue is normally nearly extinguished by adequate oxygenation (the Pasteur reaction). The highly variable concurrent stimulation of oxidative glucose catabolism contributes only a minor component to the response, and shortly passes over into a marked inhibition. (Benadryl acts similarly to pyribenzamine in this system).

The inhibitory action of these antihistaminics on the Pasteur reaction was duplicated by omitting Ca^{++} from the medium, or by adding an excess of Mg^{++} at normal calcium levels. Moreover, the Pasteur reaction is classically held to be metal-catalysed, and various metal-binding agents have previously been shown to act like the antihistaminics in activating aerobic glycolysis in incubated brain tissue. But stoichiometric considerations militate against interpretation of the present experiments on the basis of a simple complexing of the drugs with cations in the medium.

The structure of some of the most effective inhibitors of the Pasteur reaction (some phenothiazine dyestuffs) is akin to that of certain drugs employed to alter the central excitatory state, notably the tranquilizer Thorazine (chlorpromazine) which can aggravate Parkinsonian tremors, and Parsidol, which is superior to pyribenzamine and benadryl in preventing such tremors. Therefore these drugs were also tested in

terms of the cerebral glucose catabolism and proved to be very active. Moreover, in both the oxidative and the glycolytic systems definite differences were apparent between the effects of the chemically similar but pharmacologically quite different Thorazine and Parsidol (as well as various analogues). Current effort is concentrated on evaluation of an apparent correlation between the effectiveness of these agents in the control of tremor and in stimulating the cerebral oxidative sugar metabolism. This may provide a means of recognizing in vitro desirable clinical properties in compounds of this type. (P.G. LeFevre)

Boron Toxicity Studies

(6310)

The toxicity studies on borax and other inorganic boron compounds have been continued and expanded to include other animal species and the determination of potency ratios. Data are being collected from experiments in which the route of administration has been varied. (O.D. Easterday)

Toxicological Investigation of Several Organometallic Dyes

(6310)

Preliminary studies concerned with the water solubility of these organometallic dyes are continuing. Since the last report the effects of two types of protein have been investigated. The results of these studies did not suggest an improved water solubility. (O.D. Easterday)

Studies of Viability of Mouse Brain Tumor Following B¹⁰-Borax Neutron Capture Irradiation

(6310)

An initial report on these studies was made in the Quarterly Report of October 1 - December 31, 1955. These studies are being continued, with the inclusion of other boron compounds. (L.E. Farr, B.B. Antal, and O.D. Easterday)

(6310)

INTRAMOLECULAR ORGANIZATION OF ACETYLCHOLINESTERASE AS SHOWN BY IRRADIATION STUDIES. I. Serlin and G.C. Cotzias. Federation Proc. 15, 531 (1956).

Acetylcholinesterase preparations were exposed to cobalt-60 gamma rays in order to determine whether effects on submolecular units of the enzyme were demonstrable by analyzing the residual enzyme activities. Dilute preparations of partially purified electric eel organ acetylcholinesterase were irradiated with 630,000 r. Several properties, e.g., energy of activation, substrate-induced inhibition, etc., of the residual activities and of the nonirradiated control were found comparable except for a marked heat sensitivity of the irradiated samples. Apparently those molecules surviving the irradiation were damaged sufficiently to be more susceptible to heat. Likewise, the inactivation of dry samples by irradiation indicated that eel acetylcholinesterase activity was not dependent on the integrity of the entire molecule. These preparations, from either partially purified extracts or whole tissue, had identical inactivation rates which permitted calculation (after E. Pollard) of the fraction of molecular mass destroyed by single ionizing radiation events. This radiosensitive mass is of interest since it approximates a unit capable of independent activity. From calculations based on irradiation data obtained at 18°C, the target mass of eel organ acetylcholinesterase was estimated to be 235,000. Since the molecular weight is 3,000,000, the radiosensitive submolecular unit (as determined by this method) is approximately 1/13 the size

of the macromolecule. Initial irradiation studies were also carried out on three mammalian tissues. The radiosensitive unit mass of acetylcholinesterase in each of these was tentatively estimated to be: rat brain, 74,000; human red blood cells, 306,000; human plasma, 210,000. Thus, the radiosensitive acetylcholinesterase unit mass would appear to be characteristic of the tissue source and cannot be correlated with enzyme specificity at this time.

Division of Medical Physics

Boron Localization

(6310)

Neutron capture radioautography is being applied to evaluate therapeutic possibilities for Letterer-Siwe disease, a phagocytic disease which is reported to show high preferential uptake of boron colloids. The disease is characterized by wide skin involvement, with extension to lung and liver in some cases. Slides prepared from normal and pathological sections of skin have been exposed with nuclear track emulsions to demonstrate whether localization effects are adequate for the use of the $B^{10}(n, \alpha)$ reaction to be considered in the treatment of this disease. (E.E. Stickley)

Tumorogenesis by Heavy Particles

(6310)

An investigation has been initiated to determine the relative biological effectiveness of total-body irradiation with the heavy recoil particles obtained from the boron-10 capture of neutrons on tumorogenesis in the C-57 mouse strain. C-57 mice have been injected intravenously with large doses of boron-10 (160 $\mu\text{g/g}$) as borax and have then been subjected to relatively short periods of neutron exposure. These studies are in progress. (V.P. Bond, O.D. Easterday, and E.P. Cronkite)

Recovery from Total-Body Alpha Irradiation

(6320)

According to Blair's hypothesis, recovery from acute x- or gamma irradiation is approximately 90 percent complete within about six weeks in small animals; i.e., if a second dose is given six weeks or more after the first, only 10 percent of the first dose will contribute to, or add to, the effects of the second. Blair postulates that approximately 80 percent of alpha injury is permanent. It is possible to give animals acute total-body alpha radiation by injection of a neutron capture element such as boron-10, followed by total-body thermal neutron irradiation. The objective of the present experiment was to irradiate, with cobalt-60 gamma radiation, mice surviving previous exposure to large acute doses of heavy-particle radiation in order to determine the degree to which they had recovered from the initial insult. (V.P. Bond, E.P. Cronkite, and O.D. Easterday)

Medical Reactor Facility

(†)*

Short exposures required by certain pharmacological and instrumentation studies have made necessary an accurate evaluation of the effective shutter-opening curve and the uniformity of the neutron-irradiation field. Foil techniques have been used to establish these patterns, in conjunction with ionization chamber methods. A new gamma-ray monitor is being constructed to extend this work. (E.E. Stickley)

*For explanation of this symbol, see Foreword.

Medical Research Reactor

(†)

The design of the treatment ports of the medical research reactor was finalized with a uniform and clear treatment area of 8 x 8 in. maximum area. A peripheral field can be utilized with somewhat reduced flux, which permits exposure of areas up to 16 in. square. In practice this design will provide wide flexibility in the size and shape of desired exposure areas for optimum distribution of radiation. (E.E. Stickley)

Isotope Standards Comparator

(†)

Studies on the ionization chamber constructed for the determination of radioisotopes in solution have been carried out in order to continue the development of this secondary standard for precise measurements. (R.I. Weller)

(6120)

ABSOLUTE ALPHA COUNTING OF ASTATINE-211. J.K. Basson*. Anal. Chem., in press.

A method has been developed for the absolute standardization of the alpha-emitter astatine-211. The isotope is dissolved in the liquid scintillator of a scintillating counter, and thus the usual difficulties caused by absorption and scattering of the alpha particles are avoided. When a 50 g/l diphenyloxazole solution in p-dioxane was used, more than 1 cc of water could be added before the efficiency of the counter was impaired.

*Guest scientist from the National Physical Laboratory, Pretoria, South Africa.

(6120)

POTASSIUM TRANSPORT IN DUCK RED CELLS. D.C. Tosteson and J.S. Robertson. J. Cellular Comp. Physiol. 47, 147 (1956).

The concentrations of K, Na, Cl, and H₂O in duck red blood cells were measured after incubation under various conditions in vitro.

Duck red blood cells came to chloride isotopic equilibrium in less than three minutes after exposure to a medium containing Cl³⁸.

When incubated at 37°C in a medium containing 140 mM Na/l, 5 mM K/l, and glucose as substrate at pH 7.5 with 95 percent O₂ + 5 percent CO₂ as gas phase, duck red cells maintained K and Na in the steady state for many hours. All the cell K was exchangeable under these conditions. However, the approach of the cell specific activity to isotopic equilibrium after addition of K⁴² to the medium could be described by a curve containing at least two exponentials. Therefore, duck cell K under these conditions could not be considered a single, perfectly mixed compartment, but rather was kinetically heterogeneous.

When duck red cells were incubated under identical conditions except that the gas phase was 95 percent N₂ + 5 percent CO₂, the cells also maintained K and Na in the steady state for many hours, and all the cell K was exchangeable. The approach of cell specific activity to isotopic equilibrium after addition of K⁴² to the medium usually could be described by a single exponential, which indicates that cell K behaved as a single, perfectly mixed compartment. The K flux in duck cells incubated in N₂ was 28 ± 3.5 mM per liter rbc per hr, two to four times faster than either of the flux values derived from a three-compartment analysis of the exchange curve for cells in O₂.

The effects of K concentration in the medium, temperature, pH, and the composition of the gas phase and medium on K transport in duck cells are described.