200
4/15/80
AB. 1052

**LABORATORY OF NUCLEAR MEDICINE
AND
RADIATION BIOLOGY**

**UNIVERSITY OF CALIFORNIA
900 VETERAN AVENUE
LOS ANGELES, CALIFORNIA**

MASTER

ERDA CONTRACT EY-76-C-03-0012

40
DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

UCLA #12-1217

UC-48 Biology and Medicine

UNIVERSITY OF CALIFORNIA

LABORATORY OF NUCLEAR MEDICINE AND RADIATION BIOLOGY

900 VETERAN AVENUE

LOS ANGELES, CALIFORNIA 90024

This work was supported by Contract DE-AM03-76-SF00012 between the U.S.

DISCLAIMER

[illegible]

ANNUAL PROGRESS REPORT

FOR THE PERIOD

JULY 1, 1978 - JUNE 30, 1979

Printed in the United States of America. Available from Clearing house

for Federal Scientific and Technical Information, National Bureau of

Standards, U.S. Department of Commerce, Springfield, Virginia 22151.

2010-11-10 10:10:10

LEGAL NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States Government nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

TABLE OF CONTENTS

	PAGE NO.
ADMINISTRATIVE STAFF AND ADVISORS	1
REPORT OF THE DIRECTOR	2
PROFESSIONAL STAFF, GRADUATE STUDENTS AND VISITORS	
PRINCIPAL INVESTIGATORS	5
SENIOR PROFESSIONAL STAFF	7
POSTDOCTORALS	8
GRADUATE STUDENTS	8
VISITORS	9
RESEARCH HIGHLIGHTS AND ABSTRACTS OF SCIENTIFIC PUBLICATIONS	
DIVISION OF BIOMOLECULAR AND CELLULAR SCIENCE	11
DIVISION OF ENVIRONMENTAL BIOLOGY	43
DIVISION OF NUCLEAR MEDICINE	72
STAFF RECOGNITION AND HONORS	103
INDEX OF ABSTRACTS	109

LABORATORY OF NUCLEAR MEDICINE AND RADIATION BIOLOGY

UNIVERSITY OF CALIFORNIA

LOS ANGELES

DIRECTOR

O. R. Lunt

ASSOCIATE DIRECTORS

David E. Kuhl
James F. Mead
William J. Moffitt
Evan M. Romney

FACULTY ADVISORY COMMITTEE
TO THE LABORATORY

Gabriel H. Wilson
Chairman, Department of Radiological Sciences

Frederick Allen
School of Engineering and Applied Science

Jared M. Diamond
Department of Physiology

F. Harlan Lewis
Associate Dean, Life Sciences/Biology

Sherman Mellinkoff, M.D.
Dean, School of Medicine

Leonard Muscatine
Chairman, Department of Biology

Emil L. Smith
Chairman, Department of Biological Chemistry

EX-OFFICIO MEMBER

Albert A. Barber
Associate Vice Chancellor - Research

REPORT OF THE DIRECTOR

A statistical summary of Laboratory operations is to be found below. Highlights of our research accomplishments as well as more detailed reports will be found in appropriate sections.

The Laboratory's three major research programs are: Biomolecular and Cellular Science with reference to health related energy problems; Environmental Biology focusing on desert ecosystems, and Nuclear Medicine. We expect to develop a new activity next year which will interact with all three Laboratory programs, i.e., a program of technical exchange with selected Latin American countries. This program has as its objective advancing U.S. interest as well as that of cooperating countries in the areas of health and environmental research related to energy. Programs are planned for Brazil, Chile and Argentina initially and possibly one or two other countries later.

Dr. Jorge Barrio, recruited jointly by the Division of Nuclear Medicine and the Department of Pharmacology, will develop a basic program in radiopharmacology. From this work, more sophisticated physiological and metabolic labeled probes are expected to be suggested for studying the normal and disease states.

Dr. Oliver Hankinson will join the Division of Biomolecular and Cellular Science. Dr. Hankinson will have a joint appointment in the Department of Pathology with additional support from the Jonsson Comprehensive Cancer Center. He is trained in genetics and cellular biology and will strengthen the program on research into the induction of cancer --particularly the role of promoters and chemical carcinogens.

A joint search is being made for a microbial ecologist with the Department of Microbiology.

Among other changes, we report with sorrow the passing of Dr. George Taplin, former Associate Director of the Laboratory and a major contributor to the field of Nuclear Medicine.

Looking to next year, we foresee excellent progress on both basic and applied problems related to health and environmental aspects of energy development and use. Interaction by our staff with colleagues from a number of departments amplifies the effectiveness of our own efforts. It is likely that we will be doing somewhat more "assessment" work in the future and for these activities we will rely heavily on contributions from faculty outside the Laboratory. The new international program will offer some interesting opportunities to advance the Department of Energy's information and research needs.

STATISTICAL SUMMARY OF LABORATORY OPERATIONS

I. Budgeted Operating Expenditures FY 1979 (\$1,000's)

D.O.E. Base Funding	
Division of Biomolecular and Cellular Science	\$1,113
Division of Environmental Biology	1,338
Division of Nuclear Medicine	1,421
Other	<u>87</u>
	\$3,959
Non-D.O.E. Base Funding	<u>1,126</u>
Total	\$5,085

II. Space Resources (square feet)

Net assignable, Warren Hall	63,000
Assigned to Laboratory for research, Center for Health Sciences	<u>7,000</u>
Net assignable, Biomedical Cyclotron	<u>3,000</u>
	73,000

III. Staff (June 30, 1979)

Principal Investigators	24
Professional Scientific Support	18
Total Employees	191

IV. Teaching Activities (Academic Year 1978-1979)

Number of graduate students working under supervision of Laboratory staff	31
Postdoctoral trainees	24
Visiting scientists	3
Courses to which Laboratory staff have made significant contributions	53
Number of Departments in which these courses were offered	9

PRINCIPAL INVESTIGATORS

GEORGE V. ALEXANDER, M.S.

Study distribution of tracer elements in biological systems, develop spectrometric methods and equipment; computer applications

JEAN S. de VELLIS, Ph.D.

Developmental neurobiology and toxicology

ERIC B. EDNEY, Ph.D.

Physiological ecology of desert arthropods

ARMAND J. FULCO, Ph.D.

Control of lipid biosynthesis

ISAAC M. HARARY, Ph.D.

Control of mammalian cell development and specific function

ESTHER F. HAYS, M.D.

Leukemia; etiology and pathogenesis

HARVEY R. HERSCHMAN, Ph.D.

Regulation of cell division in gene expression

EDWARD J. HOFFMAN, Ph.D.

Development of new radionuclide instrumentation for diagnostic imaging and physiologic study

HENRY HUANG, D.Sc.

Mathematical modeling for radionuclide imaging of physiologic systems

DAVID E. KUHL, M.D.

Development of new radionuclide techniques for diagnostic imaging and physiologic study of local organ function

ROBERT G. LINDBERG

Physical ecology of desert rodents; environmental effects of solar thermal power systems

ACADEMIC DEPARTMENT

Anatomy

Psychiatry and Bio-behavioral Sciences

Biology

Biological Chemistry

Biological Chemistry

Medicine

Biological Chemistry

Radiological Sciences

Radiological Sciences

Radiological Sciences

Environmental Science and Engineering

PRINCIPAL INVESTIGATORS

ACADEMIC DEPARTMENT

NORMAN S. MAC DONALD, Ph.D.

Development of new cyclotron-produced radionuclides for diagnostic imaging and physiological studies

Radiological Sciences

JAMES F. MEAD, Ph.D.

Lipid metabolism in normal, aging and malignant tissue; membrane peroxidation

Biological Chemistry
Public Health

LAWRENCE S. MYERS, JR., Ph.D.

Molecular mechanisms of damage of nucleoprotein and related compounds

Radiological Sciences

KENNETH A. NAGY, Ph.D.

Vertebrate physiological ecology

Biology

HIDEO NISHITA, Ph.D.

Soil chemistry of transuranic elements - Np, Pu, Am and Cm

PARK S. NOBEL, Ph.D.

Plant physiology particularly water balance and photosynthesis

Biology

AMOS NORMAN, Ph.D.

Cell biology

Radiological Sciences

MICHAEL E. PHELPS, Ph.D.

Development of new radionuclide instrumentation for diagnostic imaging and physiologic study

Radiological Sciences

GERALD D. ROBINSON, JR., Ph.D.

Development of new radiopharmaceutical indicators for diagnostic imaging and physiologic studies

Radiological Sciences

EVAN M. ROMNEY, Ph.D.

Radionuclide and stable element cycling in plants and soils

HEINZ SCHELBERT, M.D.

Development of new radionuclide techniques for diagnostic imaging and physiologic study of local organ function

Radiological Sciences

GEORGE V. TAPLIN, M.D.

Development of new radionuclide techniques for diagnostic imaging and physiologic study of pulmonary disease

Radiological Sciences

PRINCIPAL INVESTIGATORS

FREDERICK B. TURNER, Ph.D.
Vertebrate ecology

ARTHUR WALLACE, Ph.D.
Plant physiology particularly nitrates and
trace elements in nutrition

JOHN F. WARD, Ph.D.
Molecular damage of DNA and its
modification

ROBERT A. WOOD, B.S.
Radiochemistry

ACADEMIC DEPARTMENT

Pathology

SENIOR PROFESSIONAL STAFF

ROBERT ANDERSEN, Ph.D.
JUDITH BERLINER, Ph.D.
WADE L. BERRY, Ph.D.
LES CAHAN, Ph.D.
SAWTANTRA K. CHOPRA, M.D.
GOVIND A. DHOPESHWARKAR, Ph.D.
RICHARD HUNTER, Ph.D.
ERNEST KAY, Ph.D.
HAZEL LEWIS, Ph.D.
JAMES F. MC GINNIS, Ph.D.
NIRMALA MENON, Ph.D.
ALEX SEVANIAN, Ph.D.
DAVID SIMPSON, Ph.D.
CLIVE SHIFF, Ph.D.
ROBERT A. STEIN, Ph.D.
CARL L. SIROJAN, Ph.D.
GARN A. WALLACE, Ph.D.
GUEY-SHUANG WU, Ph.D.

DIVISION

Biomolecular and Cellular Sciences
Biomolecular and Cellular Sciences
Environmental Biology
Biomolecular and Cellular Sciences
Nuclear Medicine
Biomolecular and Cellular Sciences
Environmental Biology
Biomolecular and Cellular Sciences
Biomolecular and Cellular Sciences
Biomolecular and Cellular Sciences
Biomolecular and Cellular Sciences
Biomolecular and Cellular Sciences
Biomolecular and Cellular Sciences
Environmental Biology
Biomolecular and Cellular Sciences
Environmental Biology
Biomolecular and Cellular Sciences
Biomolecular and Cellular Sciences

POSTDOCTORALS

JOSEPH P. BRESSLER, Ph.D.
DANIEL CAWLEY, Ph.D.
SYBIL L. CHEN, Ph.D.
ROBERT CHU, Ph.D.
MARTIN EPSTEIN, Ph.D.
RICHARD GAYNOR, M.D.
ROSANNE GOODMAN, Ph.D.
JOHN HARGROVE, Ph.D.
RONA KARNEY, Ph.D.
SHALINI KUMAR, Ph.D.
PAULA J. LEVEILLE, Ph.D.
FRANK J. LOMBARDI, Ph.D.
DAVID LONGSTRETH, Ph.D.
WILLIAM MAUTZ, Ph.D.
KENNETH D. MC CARTHY, Ph.D.
ABRAHAM PATHRAPANKAL, M.D.
DONALD R. ROSE, M.D.
RICHARD RUETTINGER, Ph.D.
JOSEPH SORRENTINO, Ph.D.
MICHAEL M. TATE, M.D.
RANON UDKOFF, Ph.D.
DANIEL P. WEINGARTEN, Ph.D.
JOHN WILLIAMS, Ph.D.
ROBERT WOODHOUSE, Ph.D.

GRADUATE STUDENTS

ALARIC ARENANDER, B.S.
MEL ASTRAHAN, B.S.
BRUCE BIRREN, B.A.
SUSAN BONY, B.S.
EDITH BUTLER, B.S.
HANNES CALLISEN, B.S.
TOM CAMP, B.A.
CHARLES CHANDLER, B.A.
SANDY CHAN, B.S.
GARY CIMENT, Ph.D.
PAUL COOPER, B.A.
RUSSELL DOLLINGER, B.S.
BRUCE FORELL, M.S.
PAUL FRANCO, B.A.
SUSAN GARRETT, B.A.
RONALD GETTINGER, M.A.

SPONSOR

Jean S. de Vellis
Harvey R. Herschman
Armand J. Fulco
Amos Norman
Amos Norman
Harvey R. Herschman
Harvey R. Herschman
Eric B. Edney
Govind A. Dhopeswarkar
Jean S. de Vellis
Jean S. de Vellis
Armand J. Fulco
Park S. Nobel
Kenneth A. Nagy
Jean S. de Vellis
Govind A. Dhopeswarkar
David E. Kuhl
Armand J. Fulco
Harvey R. Herschman
David E. Kuhl
Amos Norman
Jean S. de Vellis
Park S. Nobel
Park S. Nobel

SPONSOR

Jean de Vellis
Amos Norman
Harvey R. Herschman
Govind A. Dhopeswarkar
Harvey R. Herschman
Amos Norman
Amos Norman
Harvey R. Herschman
Amos Norman
Jean de Vellis
Eric B. Edney
James F. Mead
L. S. Myers, Jr.
Eric B. Edney
James F. Mead
Kenneth A. Nagy

GRADUATE STUDENTS

PETER JORDAN, B.A.
WILLIAM KARASOV, B.A.
MICHAEL KARIN, B.S.
GARY KEOUGH, M.S.
SHINICHI KITADA, M.D.
STEVEN T. LEADON, B.S.
STEVE LIPSHIE, B.A.
BROOKS MICHAELS, M.P.H.
CAL MIYAZONO, M.S.
CALVIN MYERS, M.S.
MADELEINE PINCU, B.A.
SARAH K. ROCKHOLD PIXLEY, M.S.
JAVAD RAHIMIAN, B.S.
ERNEST TERWILLIGER, B.S.
DORIS WU, M.S.

SPONSOR

Park S. Nobel
Kenneth A. Nagy
Harvey R. Herschman
Lawrence S. Myers, Jr.
James F. Mead
John F. Ward
Evan M. Romney
Jean S. de Vellis
Amos Norman
Amos Norman
Amos Norman
Jean S. de Vellis
Lawrence S. Myers, Jr.
Harvey R. Herschman
Jean S. de Vellis

VISITORS

JOHN HARGROVE, Ph.D.
Entomology

RONALD B. INGALLS, Ph.D.
Kinetic spectrophotometric pulse
radiolysis of Br₂-radical reactions
with nucleic acid components

ELIZABETH K. PERRYMAN, Ph.D.
Electron microscopy

UNIVERSITY

University of Rhodesia
Salisbury, Rhodesia

King Faisal University
Dammam, Saudi Arabia

California Polytechnic State
University, San Luis Obispo

RESEARCH HIGHLIGHTS
ABSTRACTS

DIVISION OF BIOMOLECULAR AND CELLULAR SCIENCE

RESEARCH HIGHLIGHTS

- The discovery of an irradiation-induced reaction involving bromide ions. In preliminary experiments the reaction has been found to cause extensive killing of bacteria as compared with other radiation-induced reactions.
- The discovery of a cytochrome P-450-dependent epoxidation system leading to formation of hydroxy acids in Bacillus megaterium.
- The demonstration that at least two classes of oncogenic viruses appear in the thymus and lymphoid tissue of aging AKR mice. Young animals express viruses of the same class (retroviruses) which are not oncogenic.
- The finding that a peroxidative reaction of unsaturated compounds in monolayer leading to production of lipid epoxides also occurs in lungs and other tissues in vivo, particularly in the presence of oxidative gaseous pollutants such as NO_2 .
- The proof that glucocorticoid hormones induce the synthesis of the heavy metal binding protein, metallothionein, in cultured human cells. This protein is postulated to (1) detoxify metals (Cd^{2+} , Zn^{2+}) from the environment and (2) help modulate Zn^{2+} homeostasis. These results suggest that hormone status is involved in metallothionein modulation of metal balance.
- The finding that there is a low molecular weight factor in serum that is necessary for the fusion of embryonic muscle cells and that muscle cells secrete a high molecular weight factor that can stimulate the same process. Lead, although it inhibits fusion, does not interfere with the secretion of this factor.

ABSTRACTS

1. Aharonov, A., Passovoy, D.S. and Herschman, H.R.: Mitogenic Response to Epidermal Growth Factor Relationship to Number, Affinity and Down Regulation of EGF Receptors in Three Murine Embryo Cell Lines. J. Supramol. Struct. 9:41-45 (1979).

Swiss 3T3 and C3H-M2 cells have a greater mitogenic response to Epidermal Growth Factor (EGF) than do C3H-10 $\frac{1}{2}$ cells. The latter cell line, however, has a number of EGF receptors per cell intermediate between the two cell lines which have a more vigorous response to EGF. Scatchard analysis of binding data indicate that all three cell lines have one class of EGF receptor, with indistinguishable affinity for the ligand. When exposed to 10 nM EGF all three cell lines "down-regulate" their EGF receptors with the same time course, and to the same percent of initial receptors.

2. Beardsley, T.R. and Hays, E.F.: Gross Murine Leukemia Virus-Induced Alterations in the Thymus of Preleukemic AKR Mice. Cancer Research 39:480-486 (1979).

AKR mice were inoculated with Gross murine leukemia virus at 3 days of age. Such treatment results in thymic lymphoma in all animals between 8 and 12 weeks of age. Normal AKR mice develop the disease after 28 weeks of age. In this study, virus-treated (AKR-V) and normal (AKR-N) mice were compared. Thymic weights, histology, and cell density as well as functional and mitogen assays of thymocytes and peripheral T-cells were studied. These animals were studied in the fifth week of life, a time of peak thymic size, and when the virus-inoculated mice were not yet leukemic but were a few weeks away from development of their disease.

The AKR-V mice, when compared with the normal animals, had decreased thymic weights and decreased total thymic cell density due to a loss of cortical cells. Their thymocyte response to the mitogen, phytohemagglutinin, and to alloantigen in mixed lymphocyte culture was increased significantly over that of cells from the AKR-N mouse thymus. Graft-versus-host reactivity of AKR-V thymocytes was also increased. The response to concanavalin A was significantly decreased in the AKR-V thymocytes. Treatment of the animals with cortisone resulted in a thymocyte population from both AKR-V and AKR-N mice with increased reactivity to phytohemagglutinin and concanavalin A as well as an increased responsiveness in the graft versus host reaction. T-cell responses from spleen and lymph node cells in all of the above tests were similar in the two groups, the single exception being that the AKR-V lymph node cells had a significantly higher background of thymidine uptake than did AKR-N cells. These observations suggest that loss in thymic weight of the virus-treated animals is due to a reduction

of a subpopulation of cortical cells responsive to concanavalin A. The increased reactivity to phytohemagglutinin and alloantigen in the thymus is considered to be the result of a relative increase in reactive cells produced by the reduction of cortical thymocytes.

3. Beardsley, T.R. and Hays, E.F.: Lack of Correlation Between Expression of "Amphotropic" MuLV and Oncogenicity. Amer. Assoc. for Cancer Res. 19:145 (1978).

It has become increasingly clear that more than a single MuLV entity is involved in lymphomagenesis in AKR mice. The pattern of tissue expression of the different MuLV's with age was studied in order to understand its relationship to lymphomagenesis. Bone marrow, spleen and lymph node, and thymus cells from 6 wk, 6 mos, and 9 mos old AKR mice were assayed for MuLV expression. Cells were assayed directly for infectious virus by syncytia formation on rat "XC" cells, as well as for oncogenicity in mice. In addition, they were co-cultured for 4-5 wks on NIH 3T3 cells and mink lung cells for detection of N-ecotropic and xenotropic MuLV, respectively. Subsequently, positive mink cells culture fluids were used to infect SC-1 embryo fibroblasts for assay of dual host range "amphotropic" MuLV. The presence of virus in the cultures was determined by gp 69/71 expression on the cells and reverse transcriptase activity of the culture fluids. As expected, all tissues expressed high levels of N-ecotropic MuLV which was XC positive. Xenotropic MuLV was expressed in spleen and lymph node of 6 week old mice and all lymphoid tissues and bone marrow of 6 mos and 9 mos old mice. All tissues studied of the 6 and 9 mos animals expressed oncogenic MuLV. However, amphotropic MuLV was only found in the thymus of 6 and 9 mos old AKR mice. Thus the expression of amphotropic MuLV does not correlate with oncogenicity.

4. Bony, S., Subramanian, C., Mead, J.F., and Dhopeswarkar, G.A.: Dietary Eggs and Changes in Plasma, Liver and Brain Lipids. J. Am. Oil. Chemists' Soc. 56:185A (1979).

Eggs are considered a good source of many essential nutrients such as proteins, fats, certain minerals and vitamins. They contain within their shell all the necessary nutrients for the development of embryonic life. However, egg lipids contain relatively large amounts of cholesterol and its role in health and disease is being debated. This work was undertaken to compare the effects of feeding a regular lab chow diet and feeding a diet composed of cooked whole eggs as a sole source of nutrition to pregnant female rats. Tissue analysis of both the mother rats and growing pups showed major differences. In the adult female rats at the end of 60 days on the egg diet there was: (a) only a slight elevation in plasma cholesterol ester level, (b) a threefold increase in liver total lipids, the bulk of it in the form of elevated triglycerides and a highly significant percent increase in cholesterol

ester levels. In the growing pups, obvious signs of probable multiple deficiencies were seen. Mortality rates were very high and one of the most striking features of the analytical data was a fivefold increase in brain cholesterol esters in the 12-day-old pups; normal brain lipids at this age are generally devoid of cholesterol esters. The results are discussed with respect to fatty livers in the adult female rats and the occurrence of cholesterol esters in the brains of growing pups.

5. Bottenstein, J.E. and de Vellis, J.: Regulation of Cyclic GMP, Cyclic AMP and Lactate Dehydrogenase by Putative Neurotransmitters in the C6 Rat Glioma Cell Line. Life Sciences 23:821-834 (1978).

In C6 cells, norepinephrine and dopamine caused transient increases in cyclic GMP and cyclic AMP, as well as an induction of lactate dehydrogenase. All of these responses were blocked by 1-propranolol, suggesting mediation by a β -receptor. Phentolamine potentiated the NE-increased cAMP levels by 5-fold when NE was used at suboptimal doses, suggesting the presence of α -adrenergic receptors in C6 cells. Carbamylcholine decreased the levels of both cyclic nucleotides, with hexamethonium partially reversing the effect on cyclic GMP. Dibutyl-cyclic GMP or carbamylcholine reduced catecholamine-induced cyclic AMP levels. Serotonin increased cyclic GMP levels 60% and decreased cyclic AMP levels 36%. Calcium- and magnesium-free media inhibited the norepinephrine-induced levels of cyclic GMP and cyclic AMP respectively.

6. Buchanan, J.F. and Fulco, A.J.: Formation of 9,10-Epoxy palmitate and 9,10-Dihydroxypalmitate from Palmitoleic Acid by a Soluble System from Bacillus Megaterium. Biochem. Biophys. Res. Commun. 85:1254-1260 (1978).

A soluble, cytochrome P-450-containing system from Bacillus megaterium which catalyzes the monohydroxylation of long-chain saturated fatty acids has now been found to convert palmitoleic acid to 9,10-epoxy-palmitate and 9,10-dihydroxypalmitate in addition to the expected isomeric mixture of monohydroxypalmitoleic acids.

7. Ciment, G. and de Vellis, J.S.: Cellular Interactions Cause β -Adrenergic Receptor Uncoupling from Adenylate Cyclase. J. of Supramolecular Structure 2:127 (1978).

C6 glioma cells show marked differences in the expression of differentiated functions when grown on either plastic or a bed of B104 neuroblastoma cells (both of these cloned cell lines were derived from chemically-induced rat CNS tumors). When grown by themselves, C6 cells accumulate large amounts of cAMP upon stimulation with β -agonists. However, when grown on a bed of B104 cells, the β -stimulation of cAMP is greatly attenuated, while the numbers and affinities of L-³H-

Alprenolol specific binding sites are relatively unaffected. This trophic interaction is not due to a non-specific toxicity because C6 growth continues and basal levels of Glycerol Phosphate Dehydrogenase (a differentiated function of C6) are unaffected by the presence of the neuroblastoma cells. Alternative causes of this loss in β -responsiveness, including changes in the activities of Phosphodiesterase and Adenylate Cyclase, as well as changes in the rate of cAMP release by the glial cells, have been explored.

8. Ciment, G. and de Vellis, J.: Cellular Interactions Uncouple β -Adrenergic Receptors from Adenylate Cyclase. Science 202:765-768 (1978).

C6 glioma cells and B104 neuroblastoma cells both possess adenylate cyclase activity, but only C6 cells have β -adrenergic receptors. However, when co-cultured with B104 cells, C6 cells show a marked decrease in their ability to accumulate adenosine 3',5'-monophosphate upon stimulation with β receptor agonists. Since both β receptors and cholera toxin-stimulated adenylate cyclase activities are present in C6/B104 co-cultures, we conclude that the β receptor/adenylate cyclase transduction mechanism in co-cultured C6 cells is uncoupled.

9. Dhopeswarkar, G.A. and Subramanian, C.: Lipogenesis in the Developing Brain: Utilization of Radioactive Leucine, Isoleucine, Octanoic Acid and β -Hydroxybutyric Acid. Lipids 14:47-51 (1979).

Incorporation of radioactivity from intracranially injected radioactive leucine, isoleucine (ketogenic amino acids), octanoic acid and β -hydroxybutyric acid into the brain lipids of 15 to 16 day-old rats was examined. The results showed that radioactivity from all the above precursors was incorporated into brain lipids. Radioactivity from injected isoleucine was incorporated into odd numbered fatty acids indicating an alternate pathway to α -oxidation for the biosynthesis of these fatty acids in the brain. For some as yet unclear reasons, a substantial portion of the radioactivity from injected octanoic acid was incorporated into free fatty acids. Utilization of these compounds for providing carbon for lipogenesis during development under unstressed normal conditions is discussed.

10. Foti, A.G., Copper, J.F. and Herschman, H.R.: Prostatic Acid Phosphatase and Prostatic Cancer. In Immunology and Cancer, Mathe, G. and Bona-donna, V. eds., Springer-Verlag, in press (1979).

An invited review of the development of our radioimmunoassay for prostatic acid phosphatase as a diagnostic tool for detection and monitoring of cancer of the prostate.

11. Foti, A.G., Copper, J.F., Herschman, H.R. and Sapon, S.R.: The Detection of Prostatic Cancer by Radioimmunoassay: A Review. Human Path. 9:618-620 (1978).

An invited review of the development of our radioimmunoassay for prostatic acid phosphatase as a diagnostic tool for detection and monitoring of cancer of the prostate.

12. Foti, A., Herschman, H.R. and Cooper, J.F.: The Measurement of Prostatic Acid Phosphatase in Various Cell Lines. Nat. Cancer Inst. Monographs 49:55-56 (1978).

In the last few years, we have developed a radioimmunoassay for the measurement of human prostatic acid phosphatase. This method, which requires samples of the patient's serum, has been proved to be more accurate than the conventional enzymatic assay for the detection of early stages of carcinoma of the prostate. We used the enzymatic assay and radioimmunoassay for the quantitation of prostatic acid phosphatase in cultured prostatic cell lines. We were unable to show any difference in the concentration of prostatic acid phosphatase between prostatic and any other established cell lines.

13. Fulco, A.J. and Fujii, D.K.: Adaptive Regulation of Membrane Lipid Biosynthesis in Bacilli by Environmental Temperature. In Control of Membrane Fluidity, M. Kates ed., Humana Press, Clifton, N.J., Chap. 3 (1979).

We have investigated the mechanisms in Bacillus megaterium ATCC 14581 that regulate unsaturated fatty acid biosynthesis in response to changes in environmental temperature. One process involves the irreversible, strictly first-order, inactivation of desaturase. In vivo, the half-life of the enzyme is determined solely by the culture incubation temperature and increases with decreasing temperature. This mechanism is important in regulating the rate of fatty acid desaturation in B. megaterium (and in other bacilli possessing a Δ^5 -desaturating system) during the exponential phase of cell growth.

A more complex temperature-mediated control process involves the regulation of desaturase synthesis. Cultures growing from inoculum at 35° contain neither unsaturated fatty acids nor the desaturase necessary for their production. When the culture temperature is lowered rapidly from 35° to 20°, however, synthesis of desaturase begins after a brief lag and attains a maximum rate shortly thereafter. This hyperinduction process, so-called because the rate of desaturase synthesis after culture transfer from 35° to 20° far exceeds the rate found in culture growing from inoculum at 20°, requires new protein and RNA synthesis. The maximum rate of desaturase synthesis during hyperinduction, normalized for the rate of protein synthesis, is a constant, independent of experimental conditions. The hyperinduction phase is followed by a

period of rapid attenuation until the rate of desaturase synthesis is at or below that of comparable cultures growing at 20° from inoculum. The shut-down of hyperinduction at 20° in transfer cultures as well as the lower rate of desaturase synthesis in cultures growing from inoculum at 20° appears to result from the action of a temperature-sensitive modulator protein which is absent at 35°. In the absence of modulator (i.e., during hyperinduction) the rate of desaturase synthesis is simply proportional to the overall rate of protein synthesis. Modulation, however, is an exponential function of protein synthesis. The modulator, which may be an oligomeric protein in equilibrium with an inactive monomer, seems to act at the level of transcription by selectively inhibiting the synthesis of the messenger RNA coding for desaturase. Finally, the first-order inactivation of desaturase as well as the hyperinduction and modulation of its synthesis is directly mediated by temperature. Neither the state of membrane fluidity nor wide variations in O₂-tension affect these parameters.

14. Goodman, R., Chandler, C. and Herschman, H.R.: Pheochromocytoma Cell Lines as Models of Growth Factor and Hormonally Induced Neuronal Differentiation. In Cold Spring Harbor Symposium on Cell Culture and Hormones, Ross, R. and Sato, G. eds., in press (1979).

A review of our studies concerned with EGF, NGF and dexamethasone effects on pheochromocytoma cell lines.

15. Goodman, R. and Herschman, H.R.: Nerve Growth Factor Mediated Induction of Tyrosine Hydroxylase in a Clonal Pheochromocytoma Cell Line. Proc. Nat. Acad. Sci. USA 75:4587-4590 (1978).

We have established a clonal cell line, PC-G2, from an experimentally induced rat pheochromocytoma. Administration of nerve growth factor to PC-G2 causes a four-to-eight-fold induction in the specific activity of tyrosine hydroxylase. The response is elicited in a dose dependent fashion, at concentrations above 0.1 µg/ml. Antiserum to nerve growth factor inhibited the induction of tyrosine hydroxylase. Dexamethasone enhances the nerve growth factor-mediated elevation of tyrosine hydroxylase. After three to four days of exposure to nerve growth factor the maximal induction of tyrosine hydroxylase is seen, although a significant increase can be observed after 24 hr. In contrast to the PC-12 cell line (derived from the same tumor) in which neurite outgrowth occurs in response to nerve growth factor, there is no morphological change or alteration in growth rate of PC-G2 cells after exposure to nerve growth factor.

16. Harary, I.: Biochemistry of Cardiac Development: In Vivo and In Vitro Studies. In Handbook of Physiology - The Cardiovascular System I, pp. 43-60 (1979).

Most of the information presented in this paper, concerning biochemical development, is descriptive, reflecting the present state of knowledge. Some part of the accumulated data can be helpful for visualization of possible developmental mechanisms. In many cases the early conditions surrounding the period of the development of adult proteins and structures are similar to the metabolic conditions in the adult heart. For example, the cessation of cell division and the initiation of myofibrillar protein synthesis occurs in an environment of increasing O_2 tension and aerobic metabolism. The development of mitochondria and the adult isoenzymes and metabolism are also consistent with a predominantly aerobic organ. Since high O_2 tension and redox potential tend to inhibit cell division, it is tempting to suggest that the development of the mature aerobic state is the means by which cell division is controlled. In addition, some factors, such as poly(ADPR), NAD⁺, cyclic AMP and spermine, have been shown to have an effect on DNA replication. Their increase in the developing heart is consistent with the cessation of cell division and compatible with a highly aerobic state in the mature heart.

Beyond the important problem of embryological determination is the problem of how the initiation of the synthesis of adult-specific protein is controlled. As examples, the appearance and development of proteins such as LDH, creatine phosphokinase, myosin and myoglobin have been discussed. It is clear that before we know all the factors that control the synthesis of these proteins very little can be said concerning how this control is achieved developmentally. For example, it is still not clear in all these cases whether transcription or translation is the rate-determining step.

Information is accumulating rapidly. Studies in the intact heart, in cell and organ culture, in enzymology and molecular biology, and studies with *in vitro* protein-synthesizing systems have all contributed to the present developing state of the field.

17. Hays, E.F. and Beardsley, T.R.: Interactions of Thymic Epithelial Cells, Lymphocytes and Murine Leukemia Viruses. Proceedings of Virus-Lymphocyte Interactions: Implications for Disease Symposium, Cleveland Clinical Conference, in press (1979).

AKR mice consistently develop thymic lymphoma between 7 and 14 months of age. We present evidence to explain this phenomenon and to give insight into a mechanism of viral induction of this lymphoid neoplasm. These animals have genetic factors which allow them to express endogenous murine leukemia viruses (MuLV) from birth. The viruses found in young animals of this strain are not oncogenic. In older animals viruses with oncogenic properties are found in the thymus, the target organ for lymphomagenesis, as well as in the lymphoid tissues. They are not found in the bone marrow. Animals inoculated with oncogenic AKR viruses when newborn develop thymic lymphoma between 60 and 120 days of age. A comparison was made of the thymus of these neonatally-virus-inoculated animals with that of normal mice at 29-35 days of age. This revealed

a decrease in thymic weight in the virus-treated mice which was found to be due to a loss of a specific subpopulation of cortical thymocytes. This loss of cortical cells resulted in an increased reactivity to phytohemagglutinin (PHA) and to alloantigen (both *in vivo* and *in vitro*) when thymus cell suspensions from the virus-treated mice were tested. The affected cortical thymocyte subpopulation was shown to be reactive to concanavalin A (Con A). Oncogenic MuLV was also found to exert an effect on thymic regeneration after grafting and irradiation. MuLV-treated grafts of thymic epithelium or thymus in irradiated marrow protected MuLV-treated mice, when studied 28 days after grafting or irradiation, showed a reduced total lymphocyte population with quantitatively impaired reactivity to PHA and Con A. These observations lead us to propose a theory of viral lymphomagenesis in this animal model. Stated briefly, it suggests that lymphoma develops because certain bone marrow-derived stem cells within the thymic cortex cannot differentiate under the influence of a thymic epithelium altered by the late appearing "oncogenic" MuLV. It is these differentiated cells within the thymic cortex which inhibit the inherent property of the progenitor cells to divide. Therefore, in the presence of virus-altered epithelium, continued self-replication of progenitor cells occurs. This results in the appearance of a thymic lymphoma. Under these circumstances overt lymphomas occur approximately 7-16 weeks after the stem cells entering the thymus are exposed to the virus-altered epithelium.

18. Hays, E.F. and Hale, L.: Influence of Thymic Epithelium on Colony Formation by AKR Mouse Thymocytes. Blood 52(1):226 (1978).

A feeder layer of AKR thymic epithelium (TEPI) was studied for its effect on the clonal proliferation of AKR thymocytes in soft agar. A cell line of thymic epithelium was established by culturing thymocytes for 48 hours and removing the nonadherent cells. After 4 weeks with weekly feeding the cells were subcultured. They have been maintained in continuous culture with characteristic epithelial morphology. Thymocytes and bone marrow suspensions were obtained from 7-week-old AKR mice. The culture system in 35 mm petri dishes was as follows: a monolayer of TEPI; 1 ml of McCoy's 5A medium with 20% fetal calf serum in 0.5% agar; 1 ml of medium and serum with 10^6 thymus cells or 5×10^5 bone marrow cells in 0.3% agar. The upper cell layer was studied with and without 50 μ M 2-mercaptoethanol (2ME). Colonies were counted after 10-11 days of incubation (37 degrees, 5% CO₂). Stained colonies were evaluated after removal from the agar. Colonies consisting of 40-500 cells developed in both bone marrow and thymus cultured with a TEPI underlayer and 2ME. In the absence of 2ME no thymus cell colonies were formed. Bone marrow colonies developed in equal numbers on TEPI feeder layers with and without 2ME. Thymus cells cultured with 2ME in the absence of feeder layer formed fewer and smaller colonies, than those cultured with feeder layer (25 versus 47 colonies).

Thymus and bone marrow cultured without feeder layer did not form colonies. The thymus cell colonies were composed of lymphocytes, while bone marrow showed typical granulocyte-monocyte colonies. TEPI underlayers established for 3, 4, 5 and 6 days gave comparable numbers of colonies. These results show that an epithelial cell line derived from thymus can stimulate clonal proliferation of progenitor cells in thymus and bone marrow.

19. Hays, E.F., Warren, J., Hale, L., and Rodensky, D.: AKR Murine Leukemia Viruses and Long-Term Bone Marrow Cultures from AKR and SJL Mice. Hematology, in press (1979).

We have evaluated the effects of AKR mouse retroviruses on a system of long-term bone marrow cultures which allows prolonged replication of hemopoietic stem cells, (CFUs) and granulocyte-monocyte progenitors (CFUc) with production of mature granulocytes. Ectropic-non oncogenic virus is expressed in all cultures and does not adversely effect stem cell replication. We found, however, that cultures established from mice treated *in vivo* with lymphomagenic AKR viruses (Gross murine leukemia virus and AKR SL3 murine leukemia virus) showed a more rapid decline in CFUs and CFUc than cultures from "normal" AKR mice. Only the former cultures were found to produce lymphomagenic viruses. Furthermore, it was shown that addition of lymphomagenic virus to three-week marrow cultures established from AKR and SJL mice also caused a prompt decline in progenitor cell production and granulopoiesis when compared to medium-treated control cultures.

The fate of all cultures was a loss of CFUc and granulocytes with a continuous production of macrophages. The change to macrophage production occurred earlier in the cultures treated with lymphomagenic virus or in those derived from lymphomagenic virus-treated animals. A study of these bone marrow-derived macrophage cultures, as well as cultures of similar morphology but of thymic origin, showed that they could be maintained as continuous lines. Cells from three of the cultures from lymphomagenic virus-treated animals produced locally growing sarcomas when inoculated into mice. The macrophages from the declined marrow cultures differed in certain properties from those of the established lines.

20. Herschman, H.R.: Radioimmunoassay for Serum Prostatic Acid Phosphatase and the Detection of Prostatic Cancer. Joint Congress on Clinical Chemistry, Montreal, Canada (1979).

American Cancer Society statistics suggest that 20,000 men died of prostatic cancer in the U.S. in 1977. Prostatic cancer is third only to lung and colorectal carcinoma in cancer-related deaths. The disease is most often detected by digital rectal examination of the prostate and is frequently confirmed in more advanced cases by the

enzymatic detection of elevated levels of a unique acid phosphatase, synthesized by prostatic cells, in the sera of afflicted individuals. Accurate measurement of low levels of prostatic acid phosphatase (PAP) in serum is hampered, however, by the presence of a number of other acid phosphatases; in normal serum PAP amounts to only about 10% of the total acid phosphatase activity. In addition, the enzyme activity of serum PAP is sensitive to increases in both temperature and pH.

Because of specificity, enzymatic stability and sensitivity limitations in the enzymatic determination of PAP we have developed serologic methods for the measurement of the enzyme mass in serum. We have chosen radioimmunoassay (RIA) procedures because of their reproducibility and sensitivity. PAP was purified by column chromatography from the prostatic fluid of normal males. Antisera were prepared in rabbits; each animal received approximately 250 micrograms of antigen in two injections. Purified antigen was labelled for RIA with ^{125}I by the chloramine T method. Initial RIA studies of the PAP system utilized the double-antibody method of separating free from bound antigen. However, a solid phase assay in which antibody was bound to disposable polypropylene tubes gave more rapid, reproducible, inexpensive and efficient results. The working range of the assay is 1-30 ng PAP/ml. Utilizing this assay, analysis of 150 samples require less than eight hours of labor. The specificity of the RIA for PAP was analyzed by examining cross-reactivity in twelve tissues. The maximum tissue level of cross-reactive material was only 0.1% of the activity present in a prostate extract. The PAP levels of 50 control individuals, 113 patients with prostatic cancer, 36 with benign prostatic hyperplasia (BPH), 83 with other cancers, 20 with gastro-intestinal disorders and 28 with total prostatectomies were determined by RIA and enzyme assay. When the upper limit was set at 8.0 ng/ml, the RIA diagnosed prostatic cancer in 33, 79, 71 and 82 percent of patients with Stage I, II, III and IV disease. In contrast, the enzyme assay detected elevations of enzyme in the serum of 12, 15, 29 and 60 percent respectively. No false positives were detected by either assay in normal controls; RIA was positive in two patients with BPH and one with total prostatectomy. The RIA identified over half the cases of intracapsular prostatic cancer. Preliminary screening data and longitudinal studies will also be described.

21. Herschman, H.R., Passovoy, D.S., Pruss, R.M. and Aharonov, A.: Mitogens for Murine Embryo Cell Lines. J. Supra. Struct. 8:263-268 (1978).

The growth-promoting activities of fetal bovine serum, cortisol, phorbol myristate acetate, prostaglandin $\text{F}_{2\alpha}$, insulin, epidermal growth factor and fibroblast growth factor were evaluated on four murine embryo cell lines (Swiss 3T3, Balb 3T3.M2 and C3H10T $\frac{1}{2}$). Each cell line had a unique response spectrum to this collection of reported mitogens. Phorbol myristate acetate and prostaglandin $\text{F}_{2\alpha}$

were active only on selected cell lines; cortisol was inactive on all four lines. Serum, epidermal growth factor and fibroblast growth factor were able to stimulate cell division in all four lines, albeit to varying degrees for the different target cells.

22. Herschman, H.R., Seeger, R., West, G., Stahn, R. and Uki, J.: New Neural Cell Lines Derived from Experimentally Induced Rat Tumors and From Human Neuroblastomas. Nat. Cancer Inst. Monograph 48:355-357 (1978).

We have isolated a series of new cell lines from tumors of the nervous system. Two approaches have been used. In the first, tumors were induced in neonatal rats with the potent carcinogen ethylnitrosourea. Tumors were put into cell culture and cloned after several passages. The resultant cell lines were characterized for a variety of presumptive neuronal and glial functions. Our second approach, designed to identify lines with neuronal characteristics, has been to culture and analyze cells derived from human neuroblastomas. Five lines have been characterized for the Na^+ action potential ionophore and several enzyme markers.

23. Kamberi, I.A., de Vellis, J., Bacleon, E.S. and English, D." Hormonal Patterns of the Hypothalamo-Pituitary-Gonadal Axis in the Rat During Postnatal Development and Sexual Maturation. Endokrinologie, in press (1979).

Protein or steroid hormonal levels in male and female rats from birth to adulthood were measured by radioimmunoassay. Animals were sacrificed by decapitation at 15,00 to 16,00 h (unless otherwise noted). Neonates (1 to 3 days of age) had high levels of serum gonadotropins (LH and FSH) which declined by days 5 to 7, rose sharply again at days 10 and 15, and declined a second time until the peri-pubertal period. The developmental patterns of FSH and LH were qualitatively similar in both sexes, but were quantitatively less in the males. Furthermore, the male serum FSH continued to increase slightly after day 30 and throughout the peri-pubertal period. Hormonal levels of gonadotropin-releasing hormone or gonadoliberin (Gn-RH) in the hypothalamus were detectable at day 5 in both sexes and increased rapidly between days 7 and 15. In males, this increase continued, attaining maximal values at adulthood, but the female hypothalamic Gn-RH content after day 15 was not significantly increased until the peri-pubertal period and the day of vaginal opening. The Gn-RH content in the cerebral cortical tissue of both sexes was undetectable, and the serum Gn-RH was also not detectable until a significant increase occurred in both sexes on day 15. The male serum Gn-RH continued to increase and attained maximal values at adulthood. Female maximal values were attained by day 20 and did not show any significant changes until the day of vaginal opening. In both sexes, the serum estradiol-17 β

(E₂) levels were high at birth, but they declined significantly by day 25. The E₂ levels rose again between days 10 and 20 but to a level lower than the birth value, and by day 25 they again decreased. They continued to be low in males throughout adulthood, and in females they were low until the peri-pubertal period and increased at the start of the estrus cycle. Prolactin levels in both sexes dropped slightly after birth and remained low until day 15; at day 20, a sharp increase occurred and continued to day 35 in females and to day 30 in males. Thereafter, the levels continued to decrease in males, whereas the female levels varied with the stage of the estrus cycle. Serum progesterone occurred by day 10 followed by another slight rise until day 40. By day 60, male levels were slightly lower than at days 30 to 40. Female progesterone levels increased by day 15, followed by a slight increase until days 20 to 25 and a sharp rise at days 30 to 35. Low progesterone levels were observed at the peri-pubertal period and throughout the day of vaginal opening. Hormonal levels in females at the day of vaginal opening (day of functional proestrus) and three days thereafter varied greatly. The morning of vaginal opening was characterized by a significant increase in serum E₂ levels, and the cells in the vaginal smear were cornified. The gonadotropin surge, occurring in the afternoon, was always preceded by an E₂ rise. Shortly after the gonadotropin surge, a sharp progesterone increase occurred which continued until the following day. Variations in the hypothalamic content and in the serum concentration of Gn-RH were also evident on the day of vaginal opening. The slight yet significant decline in the hypothalamic content of Gn-RH on the afternoon of proestrus was immediately reflected in a slight increase in serum Gn-RH. These changes occurred before the gonadotropin surge. The variety of hormonal changes that occurred from birth to adulthood suggests that the factors that cause the onset of puberty are very complex.

24. Kamberi, I.A. and de Vellis, J.: Peptidases in the Rat Hypothalamus Inactivating Gonadotropin-Releasing Hormone (Gn-RH). The Endocrine Society, 60th Annual Meeting, p. 172, abstract (1979).

The peptidase (arylamidase) activities and the hormones were measured spectrophotometrically and by RIA, respectively. Arylamidase activities towards specific substrates, the 5-nitroanilides of L-alanine, L-leucine, L-phenylalanine, L-tyrosine, and L-cystine have been investigated in different regions of the hypothalamus of normal male, cyclic female rats and neonatally androgenized female rats (1 mg testosterone propionate on day 3 after birth). In all hypothalamic regions examined (anterior, median eminence, posterior, lateral), it was found that the arylamidase activities with respect to these substrates decreased in the order listed above. The arylamidase activity towards L-aniline-4-nitroanilide and L-cystine-bis(4-nitroanilide) was elevated in all hypothalamic tissues as compared to the cerebral cortex. However, the

relative distribution of the activity towards these two substrates varied in different regions with more pronounced activity in the anterior hypothalamus. The arylamidase activity was considerably higher in neonatally androgenized female than in normal diestrus female rats. There was no significant difference between activity in male rats and androgenized female rats. Hypothalamic Gn-RH content was slightly elevated in the afternoon of the second day of diestrus, and remained elevated until 3:00 p.m. of the day of proestrus. At this time arylamidase activity was significantly lower. No other significant observations were noted in the rest of the four-day cycle. Hypothalamic Serum levels of luteinizing hormone (LH) were not significantly different in neonatally androgenized female and normal male, but were much higher than in diestrus female rats. These results suggest that (a) some peptidases are involved in control of turnover rate of Gn-RH throughout the estrus cycle, and (b) androgen treatment produces masculinization through activation of a mechanism responsible for Gn-RH inactivation in the hypothalamus. This in turn is reflected in changes in the gonadotropin secretion in neonatally androgenized female rats.

25. Kaplan, B.B., Schachter, B.S., Osterburg, H.H., de Vellis, J.S. and Finch, C.E.: Sequence Complexity of Polyadenylated RNA Obtained from Rat Brain Regions and Cultured Rat Cells of Neural Origin. Biochemistry 17:5516-5524 (1978).

The nucleotide base sequence complexity of total poly(A) RNA from rat tissues and cultured cells of neural origin was measured by RNA-driven hybridization reactions with nonrepetitive [³H]DNA. At saturation, liver and whole brain poly(A) RNAs were complementary to an average of 6.8 and 12.3%, respectively, of the nonrepetitive DNA. Assuming asymmetric transcription, the complexity of liver and brain poly(A) RNAs were equivalent to 3.6 and 6.5×10^8 nucleotides, respectively. The complexity of whole brain poly(A) RNA was similar to that from major functionally distinct brain regions: cerebellum, hypothalamus, hippocampus, and cerebral cortex. Considerations of experimental variance suggest that total poly(A) RNA sequence overlap between major brain regions is substantial and may be $\geq 80\%$. Cultured cells of neural origin had poly(A) RNA complexities which were intermediate between liver and brain in the order: liver < primary glial cultures from 3-day-old brain (predominantly astrocytes) < neuroblastoma (B104) < glioma (C6) < brain. Hybridization of combinations of RNA from the sources indicates extensive similarities in poly(A) RNA sequences between neuroblastoma, glioma, and glial cells and suggests that most liver and neuroblastoma poly(A) RNA sequences are a subset of those in the brain. Comparison of data from this and other studies suggests that cultured cells of neural origin may, like the fully differentiated brain, have an unusually complex RNA population. If these findings reflect the situation in vivo, the large complexity and homology of

neuronal and glial RNA could underlie the similarities in poly(A) RNA sequence complexity observed between different brain regions. The hybridization kinetics of poly(A) RNA from whole brain and from functionally distinct brain regions were comparable and revealed at least two kinetic classes. The most slowly hybridizing RNA component hybridized with a pseudo-first-order rate constant of $1.9 \times 10^{-4} \text{ L mol}^{-1} \text{ s}^{-1}$ and contained 70% of the poly(A) RNA complexity. The fraction of the poly(A) RNA driving the slow reaction was 4% of its mass. From these figures it is calculated that each slowly hybridizing poly(A) RNA sequence is present in about 0.03 copy per brain cell. This suggests that each brain region studied contains at least 30 different cell classes distinguished by poly(A) RNA sequence content.

26. Karin, M. and Herschman, H.R.: Dexamethasone Stimulation of Metallothionein Synthesis in HeLa Cell Cultures. Science 204:176-177 (1979).

HeLa cells in culture synthesize metallothionein. To investigate the effects of glucocorticoids on metallothionein synthesis we adapted HeLa cells to growth in a defined medium lacking hydrocortisone. In this defined medium, containing $1.5 \times 10^{-6} \text{ M Zn}^{2+}$, dexamethasone (10^{-6}) caused a five- to sixfold increase in the synthesis of metallothionein. Progesterone (10^{-5} M), a known antagonist of glucocorticoids, inhibited this response by 50 percent.

27. Karney, R.I. and Dhopeswarkar, G.A.: Metabolism of All trans 9,12- $[1-^{14}\text{C}]$ Octadecadienoic Acid in the Developing Brain. Biochimica et Biophysica Acta 531:9-15 (1978).

Eicosatetraenoic acid (20 : 4) isolated from the brains of 12-day old rat pups, 8 h after intraperitoneal injection of either all cis or all trans 9,12- $[1-^{14}\text{C}]$ octadecadienoic acid, revealed distinctly different patterns of radioactivity distribution in terms of relative carboxyl activity.

$$\% \text{ relative carboxyl activity} = \frac{\text{radioactivity in the carboxyl carbon}}{\text{radioactivity in the total fatty acid}} \times 100$$

Although radioactivity was measured in the total fatty acid, in the case of arachidonate, this represents radioactivity in the first three carbons only since 20 : 4 is not synthesized de novo. The high percentage relative carboxyl activity value in brain 20 : 4, following $[1-^{14}\text{C}]$ linoleate injection indicated a lack of direct conversion of all trans 18 : 2 to 20 : 4. However, the relative lower percentage relative carboxyl activity in brain 20 : 4, after injection of $[1-^{14}\text{C}]$ linoleate, indicated direct conversion of the all cis 18 : 2 to 20 : 4. Similar, but more pronounced, label distribution differences in brain 20 : 4, following intracranial injection of the two tracers, confirmed this metabolic difference. Further isolation and analysis of brain polyunsaturated fatty acids after intracranial injection revealed that

- all trans 9,12-18 : 2 was elongated to 11,14-20 : 2 and was also de-saturated to give 6,9,12-18 : 3 followed by elongation to form 8,11,14-20 : 3. This indicated that the conversion of the all trans 9,12-18 : 2 to 20 : 4 was blocked at the Δ^5 -desaturation of 8,11,14-20 : 3 to 5,8,11,14-20 : 4 rather than at the Δ^6 -desaturase step of 9,12-18 : 2 to 6,9,12-18 : 3.
28. Karney, R.I. and Dhopeswarkar, G.A.: Trans Fatty Acids: Positional Specificity in Brain Lecithin. Lipids 14:257-261 (1979).

Fifteen-day-old rats were divided into three groups: one group received an intracerebral injection of 5 μ Ci of 9-trans [1- 14 C] octadecadienoic acid; the second group was given 5 μ Ci of the same compound plus an equal wt of nonradioactive all cis arachidonic acid; the third group was given 5 μ Ci of 9-trans [1- 14 C]octadecenoic acid. All animals were sacrificed 8 hr after injection. Glycerophosphocholine (GPC) was isolated and partially decylated with phospholipase A₂ from Crotalus Adamenteus venom. The results of this study were as follows: 1) after tt[1- 14 C]18:1 injection, there was twice as much radioactivity in the 1-position as in the 2-position; 2) when tt[1- 14 C]18:2 was injected, more than 90% of the total radioactivity was found in the 2-position; 3) following tt [1- 14 C]-18:2 + nonradioactive arachidonic acid injection, ca. 75% of the total radioactivity in the 2-position; and 4) all of the injected [1- 14 C]-tracers showed evidence of undergoing β -oxidation to form acetyl-CoA, which was converted to radioactive palmitate. The possibility is discussed that the observed distribution pattern of the injected radioactive tracers may be attributed to tissue metabolic specificity. Ramifications of the deposition of dietary trans fatty acids in the brain during the developmental stage of the central nervous system are also discussed.

29. Kay, E.: Structure-Function Relationships of Proteinase Inhibitors from Soybean (Bowman-Birk) and Lima Bean. J. of Biological Chemistry in press (1979).

Contributions of tyrosyl residues to trypsin- and chymotrypsin-inhibitory activities in two homologous proteinase inhibitors were investigated by modifying them with N-acetylimidazole under various conditions. In Bowman-Birk soybean proteinase inhibitor, Tyr 55, immediately following the antichymotryptic site, Leu 53-Ser 54, is relatively inaccessible to N-acetylimidazole and can only be acetylated in the presence of 6 M guanidine hydrochloride but not in 8 M urea. The acetylation of Tyr 55 is accompanied by 60% loss in antichymotryptic activity. Decacetylation with hydroxylamine restores the activity to the original level. Tyr 69, located in the antitrypsin portion of the inhibitor, is exposed relatively to N-acetylimidazole and can be acetylated without denaturing agent. The acetylation of

Tyr 69 parallels decrease in antitryptic activity. The inhibitor acetylated at Tyr 69 is fully active toward chymotrypsin and has 30 to 40% antitryptic activity of the native. The original level of antitryptic activity is restored upon deacetylation.

Tyr 69 of lima bean proteinase inhibitor is relatively inaccessible to N-acetylimidazole: 75% acetylation in the presence of 6 M guanidine hydrochloride and 17% without the denaturing agent. The acetylated inhibitor is fully active toward chymotrypsin but retains only 29% (acetylated without guanidine hydrochloride) and 17% (acetylated with guanidine hydrochloride) of the original antitryptic activity. Deacetylation partially restores the lost antitryptic activity in the inhibitor acetylated without the denaturing agent.

The total and irreversible loss of antitryptic activity in samples acetylated in the presence of 8 M urea or 6 M guanidine hydrochloride is attributed to the acetylation at the ϵ -amino group of Lys 26 at the trypsin-inhibitory site.

30. Kay, E. and Gumbiner, B.: Lima Bean Proteinase Inhibitor. J. of Biochemistry, in press (1979).

Origins of CD bands in lima bean proteinase inhibitor were deduced from an acetylation-deacetylation study of the sole tyrosyl residue in the protein (Tyr 69), and by analogy with Bowman-Birk soybean proteinase inhibitor, a homologous protein with similar spectral properties.

Tyr-69 is relatively inaccessible to N-acetylimidazole; 100-fold molar excess of the reagent in the presence of 6 M guanidine hydrochloride elicited about 70 to 80% O-acetylation. A broad negative CD band centered around 280 nm arises mainly from the longest wavelength transition of cystinyl side chains ($\epsilon_L - \epsilon_R = -0.8 \text{ M}^{-1} \text{ cm}^{-1}$ per disulfide). The second cystinyl transition gives rise to a positive CD band of a comparable intensity at 247 nm. The 1L_b vibronic transition of Tyr 69 has negative CD around 280 nm, contributing approximately 10% of the total CD intensity at 278 nm ($\epsilon_L - \epsilon_R = -0.5 \text{ M}^{-1} \text{ cm}^{-1}$). The 232 nm positive shoulder is from the 1L_a vibronic transition of Tyr 69.

Radical anions, Br_2^- and $(\text{CNS})_2^-$, generated by the irradiation of N_2O -saturated inhibitor solutions containing KBr or KCNS, reduced tyrosyl CD without affecting disulfide CD bands, indicating that the radical anions damaged Tyr 69 without altering protein conformation. The inhibitor modified at Tyr 69 by Br_2^- and $(\text{CNS})_2^-$ retained full activity toward trypsin and chymotrypsin. The irradiation of the inhibitor in the air-saturated solution led to loss in tyrosyl as well as cystinyl CD bands and decline in both antiproteinase activities.

31. Kitada, S., Mead, J.F. and Hays, E.F.: Lipid Mobilization in Lymphoma-Bearing Mice. J. Am. Oil Chemists' Soc. 56:192A (1979).

1-¹⁴C-Linoleic acid was fed to healthy AKR mice, and the resulting labeled adipose tissue was transplanted into the peritoneal cavity of age-matched lymphoma-bearing and control AKR mice. Significant amounts of radioactivity were found after 3 days in liver, thymus, and lymph nodes in lymphoma-bearing mice, whereas only negligible amounts of radioactivity were found in liver and thymus of control mice. In thymus, which was almost totally replaced by lymphoma cells, the radioactivity was found to be about 90% in the phospholipid fraction. These results are consistent with the idea that lipid mobilization is taking place in the lymphoma-bearing mice and that triglyceride fatty acids from adipose tissue are furnishing fatty acids for membrane synthesis and possibly for energy in the growing tumor cells.

32. Lewis, H.L., Muhleman, D.R. and Ward, J.F.: Serologic Assay of DNA Base Damage. I. 5-Hydroxymethyldeoxyuridine, A Radiation Product of Thymidine. Radiat. Res. 75:305-316 (1978).

We have developed a serologic assay for 5-hydroxymethyldeoxyuridine, (5-HMUDR) an ionizing radiation product of thymidine. Antibodies were prepared to a bovine serum albumin conjugate of 5-hydroxymethyluridine (5-HMUR). Using phage neutralization assay 0.1 nmole of 5-HMUR can be detected. The antiserum cross-reacted with thymidine but with no other naturally occurring DNA components. There was cross-reaction with uridine, 6-methyluracil, and the halogenated analogs of thymidine. Interference by cross-reaction with thymidine was eliminated by saturation of the assay with excess thymidine. Three micromolar (0.3 nmole 0.1 ml) 5-HMUR can be detected in the presence of 8 mM thymidine. The assay was applied to the estimation of 5-HMUDR produced by γ irradiation of thymidine in O₂. The G value for product formation was 0.05. Irradiation at pH 14 greatly increased the yield. There was a threefold increase in G value when irradiated samples were heated at pH 9 or treated with 10⁻³ M ferrous ions, postirradiation procedures which convert thymidine methylperoxides to 5-HMUDR. This suggests that cross-reaction with the peroxide is not extensive. Estimation of 5-HMUDR in DNA irradiation in O₂ gave a G value roughly the same as that found in irradiation of thymidine. This yield is based on the assumption that antibody reacts equally with the 5-HMU moiety in DNA and as the mononucleoside. 5-HMUDR was detected as one nucleoside per 3 x 10⁶ daltons of DNA.

33. McCarthy, K.D. and de Vellis, J.: Preparation of Separate Astroglial and Oligodendroglial Cell Cultures. Transactions, Amer. Soc. Neurochem. 10:129 (1979).

A novel method has been developed for the preparation of nearly pure separate cultures of astroglia and oligodendroglia. The method is based on (i) the absence of viable neurons in cultures prepared from postnatal rat cerebra, (ii) the stratification of astroglia and oligodendroglia in culture and (iii) the selective detachment of the overlying oligodendroglia when exposed to sheer forces generated by shaking the cultures on an orbital shaker for 15-18 h at 37°C. Preparations appear greater than 98% pure and contain approximately $1-2 \times 10^7$ viable cells (20-40 mg of cell protein). Three methods were used to characterize these two culture types. First, electron microscopic analyses were utilized to identify the cells in each preparation (mixed and separated cultures of astroglia and oligodendroglia) and to assess the purity of each preparation. Second, two oligodendroglial cell markers, cyclic nucleotide phosphohydrolase and glycerol phosphate dehydrogenase, were monitored and found localized in oligodendroglial cell cultures. Third, the ability of α -adrenergic agonists to modulate cAMP accumulation was restricted to astroglial cultures. In addition to these studies, we examined the influence of brain extract and dibutyryl cAMP on the gross morphology and ultrastructure of each preparation. These agents induced astroglial process and filament formation without any apparent morphological effect on oligodendroglia. Taken together the results indicate that essentially pure cultures of astroglia and of oligodendroglia can be prepared and maintained. These preparations should significantly aid our efforts to examine the pharmacology and biochemistry of these two major classes of central nervous system cells.

34. McCarthy, K.D. and de Vellis, J.: Regulation of β -Adrenergic Agonist, PGE₁ and Adenosine Increased cAMP Levels by α -Adrenergic Agonists in Primary Glial Cultures. Seventh International Congress of Pharmacology, Paris, abstract (1978).

Beta-adrenergic agonists, adenosine and prostaglandin E₁ increased the level of adenosine 3' : 5'-monophosphate (cAMP) in glial cultures prepared from rat cerebral cortical tissue. In addition to these physiological effectors, cholera toxin also increased cAMP levels in these cultures. The accumulation of cAMP in response to each of these agents, including cholera toxin, was partially blocked (50-80%) by simultaneous α -adrenergic receptor stimulation. Basal levels of cAMP were not affected by α -adrenergic agonists. These results indicate that in glia, α -adrenergic receptors may serve to modulate neurohumoral substances. The modulatory effect of α -adrenergic agents does not appear to reduce cAMP accumulation by activating phosphodiesterase since the effect was not blocked by a potent inhibitor of this enzyme. The results suggest that the modulatory effect of α -adrenergic receptor activation results from an interaction which takes place at some point in between adenylate cyclase-associated-membrane receptors and the enzymatic degradation of cAMP.

35. McCarthy, K.D. and de Vellis, J.: The Regulation of Adenosine 3' :5'-Cyclic Monophosphate Accumulation in Glia by Alpha-Adrenergic Agonists. Life Sciences 24:639-650 (1979).

This study examines the α -adrenergic modulation of cAMP accumulation in glia. This phenomenon occurs in three different glial culture systems: (a) primary surface cultures of glia, (b) reaggregate cultures containing neurons and glia, and (c) C6 glioma cells. The turn-on and turn-off times of α -adrenergic modulation appear to be in the same time frame as that of agents which normally increase cAMP accumulation. However, even after prolonged treatment periods, refractoriness does not develop to the modulating capacity of α -adrenergic agents. Clonidine, reported to act as both an α -adrenergic agonist and antagonist in the central nervous system, was found to interact with glia as an α -adrenergic agonist. Alpha-adrenergic modulation was not diminished by the addition of ethylene-glycol-bis-(β -amino-ethyl ether)N,N'-tetra-acetic acid (EGTA) to culture media, suggesting that external calcium is not required for this effect. These results illustrate the complexity of glial pharmacology and need for more defined systems which allow the examination of characterized populations of brain cells.

36. McGinnis, J.F. and de Vellis, J.: Glucocorticoid Regulation in Rat Brain Cell Cultures. Hydrocortisone Increases the Rate of Synthesis of Glycerol Phosphate Dehydrogenase in C6 Glioma Cells. J. of Biological Chemistry 253:8488-8492 (1978).

Cytoplasmic glycerol phosphate dehydrogenase (sn-glycerol-3-phosphate: NAD⁺ 2-oxidoreductase, EC 1.1.1.8) was rapidly purified from rat skeletal muscle in high yield using a combination of classical and affinity techniques. A single band of protein having a molecular weight of 30,000 was found using dodecyl sulfate-poly acrylamide gel electrophoresis. Antisera were generated in rabbits against the purified enzyme and demonstrated to be monospecific by Ouchterlony immunodiffusion against crude homogenates from hydrocortisone-induced and uninduced C6 cells. All of the radioactivity in immunoprecipitates from [³H]leucine-labeled cells co-migrated with purified glycerol phosphate dehydrogenase. The amount of radioactivity precipitated was directly proportional to the amount of labeled glycerol phosphate dehydrogenase present, indicating that the assay could be used to quantitate newly synthesized glycerol phosphate dehydrogenase molecules. Using these techniques, the induction of glycerol phosphate dehydrogenase activity by hydrocortisone in the C6 glioma cell line was shown to be due to an increase in the rate of synthesis of the enzyme. Analysis of the kinetics of induction and deinduction supports the above conclusion and suggests that there is essentially no change in the rate of degradation of glycerol phosphate dehydrogenase in the presence

and absence of hormone. The enzyme activity and immunological reactivity of glycerol phosphate dehydrogenase in C6 cells decay simultaneously, suggesting that the entire molecule is degraded when enzyme activity is lost. The increased rate of synthesis can be prevented by inhibition of RNA synthesis with actinomycin D or amanitin, but it is only partially inhibited by cordycepin, suggesting that some of the glycerol phosphate dehydrogenase mRNA's do not require poly(A) sequences to be translated. Surprisingly, the accumulation of specific mRNA for glycerol phosphate dehydrogenase appears to require protein synthesis. This is evidenced by the failure to "rescue" glycerol phosphate dehydrogenase mRNA following the wash out of cycloheximide. Following removal of hydrocortisone, the mRNA for glycerol phosphate dehydrogenase decays with a half-life of approximately 2½ h.

37. McGinnis, J.F. and de Vellis, J.: Glycerol-3-phosphate Dehydrogenase Isoenzymes in Human Tissues: Evidence for a Heart-specific Form. J. of Molecular and Cellular Cardiology, in press (1979).

Incubation of homogenates, from human heart, brain, liver and skeletal muscle, with excess antiserum against purified rat skeletal muscle glycerol phosphate dehydrogenase (L-glycerol-3-phosphate:NAD⁺ oxidoreductase, EC 1.1.1.8) demonstrated the presence of two immunologically distinct forms of enzyme. The major form of the enzyme in heart tissue does not react with the antibody and is very heat labile. Anion exchange chromatography resulted in the separation of heart glycerol phosphate dehydrogenase into three peaks, each of which was distinguishable from the others by heat lability and immunological reactivity. The isoenzymes appear to represent combinations of two different subunits to produce HH, HL and LL forms with HH representing the major heart isoenzyme and LL the liver. The data suggests that the detection of the HH isoenzyme in serum may be used as an indicator to diagnose cardiac infarctions in humans.

38. McGinnis, J.F. and de Vellis, J.: Immunologically and Biochemically Distinct Forms of Glycerol Phosphate Dehydrogenase (GPDH) in Human Heart. Fed. Proc. 38:531 (1979).

Incubation of homogenates, from human heart, brain, liver and skeletal muscle, with excess antiserum against purified rat skeletal muscle glycerol phosphate dehydrogenase (L-glycerol-3-phosphate:NAD⁺ oxidoreductase, EC 1.1.1.8) demonstrated the presence of two immunologically distinct forms of the enzyme. The major form of the enzyme in heart tissue does not react with the antibody and is very heat labile. Anion exchange chromatography resulted in the separation of heart glycerol phosphate dehydrogenase into three peaks, each of which was distinguishable from others by heat lability and immunological reactivity. The kinetics of heat inactivation (at 480)

of the separated forms demonstrated that the major form of GPDH in heart had a half-life of 2.0 min whereas the other two forms had half-lives of 40 min and 100 min. These forms have the same molecular weight (~74K) since they cochromatograph on Sephadex G-200. The three forms appear to represent combinations of two different subunits to produce HH, HL and LL forms with HH representing the major heart isoenzyme and LL the liver. The data suggest that the detection of the HH isoenzyme in serum may be used as an indicator to diagnose cardiac infarctions in humans.

39. Mead, J.F., Gan-Elepano, M. and Hirahara, F.: Initiation of Peroxidation by NO₂ in Natural and Model Systems. Symposium on Health Effects of Nitrogen Oxides, Lee, S.D. ed., in press (1979).

It is well-known that membrane lipids are subject to peroxidation both in vitro and in vivo, particularly if they contain a high proportion of polyunsaturated fatty acids (PUFA) or are from tocopherol-deficient animals. The result is damage to the integrity of the membrane itself and to some of its constituents, such as enzymes and transport systems. Membrane peroxidation can be induced in several ways, including exposure to radical-generating systems such as Fe²⁺-ascorbate and certain oxidative gases, such as NO₂ and O₃.

In this laboratory, a microsomal vesicle system has been found to undergo peroxidation when incubated in the presence of Fe²⁺ + ascorbate and in atmospheres containing NO₂. However, the types of reactions appear to be different. In the Fe²⁺ + ascorbate system, tocopherol is slowly oxidized and the PUFA, 20:4 and 22:6, decrease, particularly if the tocopherol content is low at the start (vitamin E-deficient rats). With incubation in the presence of NO₂, however, tocopherol is quite rapidly oxidized while PUFA remain unchanged.

In order to interpret these results, use is being made of a simple model system consisting of a monolayer of linoleic acid adsorbed on silica gel. In this system, linoleic acid disappears with first order kinetics and with production of isomeric epoxyoctadecenoates as major products. In the presence of tocopherol, an induction period occurs which is proportional to the mole percent of tocopherol present in the monolayer. At the end of the induction period, tocopherol has been largely oxidized and this is hastened by incubation in the presence of NO₂.

The differences in peroxidation mechanisms initiated by NO₂ and by the Fe²⁺ + ascorbate system are discussed in terms of the reactivity of the initiating substances and the arrangement of PUFA and other substances in the vesicles and the model system.

40. Mead, F.J., Sevanian, A., Stein, R.A. and Wu, G.-S.: Lipid Peroxidation in Model and Natural Membranes. In Oxygen: Biochemical and Clinical Aspects, Caughey, W.S. ed., Academic Press, in press (1979).

A monolayer of linoleic acid adsorbed on silica has been used to predict certain aspects of lipid peroxidation in biomembranes. Major products of this reaction are epoxides of fatty acids or other olefins, such as cholesterol, that are included in the monolayer. Analysis of the lipids of lung tissue and lung lavage of rats revealed similar products leading to the idea that a similar, probably nonenzymatic peroxidation was occurring. These products were generally increased in lungs of rats exposed to 6 ppm NO₂ for 24 hr. The known mutagenic and carcinogenic properties of many epoxides leads to a study of means of prevention of the reaction by antioxidants.

41. Moyer, G.H., Kay, E. and Austin, G.E.: Differences in the Circular Dichroism Spectra of Eu- and Heterochromatin Fractions from Rat Liver. Nucleic Acids Research 6:1657 (1979).

Significant differences are observed between the CD spectra of eu- and heterochromatin prepared by fractionating mechanically sheared rat liver chromatin on linear sucrose density gradients. Heterochromatin has a broad positive CD at 270-280 nm, a cross-over point at 256 nm, and a negative shoulder at 248 nm. Euchromatin displays a shift in the positive peak to 267 nm and the cross-over point to 254 nm, as well as an intensification of the 267 nm peak. The negative shoulder at 248 nm is absent in euchromatin. These spectral differences between eu- and heterochromatin are present in both low and high ionic strength media. Mechanical shearing does not induce CD alteration and anomalous light scattering is absent in our system. The greater RNA content of euchromatin compared to heterochromatin cannot account for the spectral differences. These results suggest that the DNA conformation of euchromatin is distinct from that of heterochromatin and they may provide clues to the reasons for the greater transcription of euchromatin.

42. Myers, L.S., Jr.: Free Radical Damage of Nucleic Acids and Their Components: The Direct Absorption of Energy. In Free Radicals in Biology, Pryor, W.A. ed., Academic Press, New York, Vol. IV, in press (1979).

This study is an attempt to extract from the vast literature on radiation effects on solid compounds information relevant to processes which may actually occur when living organisms are irradiated. Topics covered include: i) initial radical products; ii) reactions of initial products and identification of secondary products; iii) effects of LET, light, and metal ions on radical structure and stability; and iv) interactions such as charge and radical transfer between bases when stacked in various conformations.

43. Myers, L.S., Jr. and Kay, E.: Radiolysis of DNA and Proteins. Int. J. Radiat. Oncology, Biol. and Phys., in press (1979).

Studies of radiolysis of biopolymers serve the dual purposes of giving information on a) chemical mechanisms by which radiation modifies life processes and b) structure-function relationships in macromolecules. Conditions in living cells are such that both direct and indirect depositions of energy in biopolymers are possible. Direct effects in chromatin components result in formation of specific radical products, many highly reactive. In irradiated DNA the cationic radical, $\cdot\text{Gua}^+$, and the anionic radical, $\cdot\text{Thy}^-$, make large contributions to the ESR spectrum. Secondary reactions of the cationic radicals are largely unknown. Indirect effects occur when energy is deposited in water or other components in a solution, and radiolysis products such as $\cdot\text{eag}^-$ and $\cdot\text{OH}$ react with the biopolymer under investigation. Studies carried out half a century ago show that this process is effective in inactivating enzymes. Conversion of $\cdot\text{OH}$ to the less reactive inorganic radical-anion $\cdot\text{Br}_2^-$ has made it possible to determine the role of tyrosine in functional and structural integrity of several proteinase inhibitors. Both $\cdot\text{eag}^-$ and $\cdot\text{OH}$ react rapidly with DNA, but only $\cdot\text{OH}$ initiates reactions which damage DNA. Radiolysis of double-stranded DNA leads to an increase in optical absorption. The $\cdot\text{OH}$ is believed to attack the deoxyribose moiety, causing strand breaks and partial denaturation, thus reducing the hypochromic effect. After the DNA is partially denatured, or single-stranded, $\cdot\text{OH}$ attacks the bases also. Three kinds of strand breaks have been observed: 1) immediate, 2) those appearing post-irradiation, and 3) those appearing on postirradiation treatment with alkali. Radiolysis of chromatin results in DNA strand breaks, base damage, and protein-DNA cross links. Yields for strand breaks and base damage are lower in chromatin than in purified DNA, and lower still in intact cells. A general hypothesis for radiation damage of chromatin is outlined.

44. Myers, L.S., Jr., Warnick, A., Ingalls, R.B. and Kay, E.: Oxidation of Bases Within Double-Stranded DNA by Radiolysis of Anoxic Bromide Solutions. Abstracts, 6th International Congress of Radiation, Tokyo, p. 190 (1979).

The bases of intact, double-stranded DNA are at least partially protected from hydroxyl free radical ($\cdot\text{OH}$) oxidative attack during exposure to low radiation doses. (Ward and Kuo 75:278, 1978). This protection does not occur in N_2O -saturated bromide solutions in which $\cdot\text{OH}$ and hydrated electrons are converted to $\cdot\text{Br}_2^-$ radical anion. Instead, bases are oxidized with the same yield (bases destroyed per rad) as is observed in the absence of bromide with single-stranded DNA, or with double-stranded DNA after exposure to large radiation doses. Experiments with model compounds show that bases, and base moieties of nucleosides and nucleotides are oxidized when bromide is present,

but deoxyribose moieties appear to be unaffected. Oxygen in bromide solutions partially inhibits the oxidation of DNA components, and completely inhibits oxidation of DNA. These results suggest that in bromide solutions base moieties of DNA are destroyed by a mechanism, possibly electron transfer, which differs from that of OH attack (free radical addition to a double bond), and that oxygen can compete with DNA and its components for the reactive species in bromide solutions. Such a mechanism may be important in the action of radiation sensitizers. Complementary pulse radiolysis studies and product analyses are in progress.

45. Nowinski, R.C. and Hays, E.F.: Oncogenicity of AKR Endogenous Leukemia Viruses. J. of Virology 27:13-18 (1978).

Four biologically distinct groups of endogenous murine leukemia virus (MuLV) have been isolated from AKR mice. These viruses include (i) ecotropic XC⁺ MuLV that occur in high titer in normal tissues and serum of AKR mice throughout their life span, (ii) ecotropic XC⁻ MuLV that are produced in high titers by leukemia cells, (iii) xenotropic MuLV that are readily demonstrable only in aged mice, and (iv) polytropic MuLV that arise in the thymuses of aged mice as a consequence of genetic recombination between ecotropic and xenotropic MuLV. Viruses of each of these biological classes were assayed in AKR mice for their ability to accelerate the occurrence of spontaneous leukemia. Certain isolates of ecotropic XC⁻ MuLV and polytropic MuLV were found to have high oncogenic activity. These viruses induced 100% leukemias within 90 days of inoculation. In contrast, ecotropic XC⁺ MuLV that were obtained from the lymphoid tissues of aged AKR mice did not demonstrate oncogenic activity. These findings demonstrate fundamental differences between XC⁻ and XC⁺ ecotropic MuLV that are found in leukemic and normal tissues, respectively. Furthermore, these findings point to the role of ecotropic XC⁻ and polytropic MuLV in the spontaneous leukemogenesis of AKR mice.

46. Pruss, R.M. and Herschman, H.R.: Cholera Toxin Stimulates Division of 3T3 Cells. J. Cell. Physiol. 98:469-473 (1979).

Cholera toxin was used in an attempt to inhibit epidermal growth factor stimulated 3T3 cell division. Instead, cholera toxin alone at low concentrations (10^{-10} M), was able to stimulate cell division and could augment EGF stimulated cell division. The mitogenic effect of cholera toxin can occur despite a dramatic increase in the intracellular levels of cAMP in 3T3 cells. Cholera toxin stimulated mitogenesis could not be mimicked by cholera genoid, the binding but inactive subunit of cholera toxin, or by other agents which elevate cAMP levels in 3T3 cells.

47. Ramsey, R. and Hays, E.F.: Factors Promoting Colony Stimulating Activity (CSA) Production in Macrophages and Epithelial Cells. J. Exp. Hemat., in press (1979).

Colony stimulating activity (CSA) is a hormone that stimulates differentiation of granulocytes in animals and man. The regulation of CSA release from CSA producing cells is a poorly understood process. Using freshly isolated mouse peritoneal cells and a continuous line of mouse thymic epithelial cells, a precise and reproducible method of short term culture was developed to study this phenomenon. Serum, endotoxin, lithium, and cyclic GMP stimulated CSA release from both cell types. Particles such as zymosan, inulin, latex, and iron filings stimulated CSA release from mouse peritoneal macrophages which phagocytose the particles, but not from nonphagocytic thymic epithelial cells. Theophylline and cyclic AMP inhibited CSA release from both cell types. Trypsin activated guinea pig C3 and C5 did not stimulate CSA release. Cycloheximide, an inhibitor of protein synthesis, completely inhibited CSA release. We believe these findings reflect mechanisms of in vivo regulation of release of the granulopoietic hormone, CSA.

48. Rudd, C.J. and Herschman, H.R.: Characterization of Metallothionein in a Human Cell Line. Presented at 18th Annual Meeting of the Society of Toxicology, New Orleans, LA, March (1979).

Synthesis of metallothionein (MT) can be induced in the liver and kidney by cadmium or zinc salts and MT has been found in a number of other organs. MT synthesis was also induced in a clonal rat liver cell line (RLC-GAI). MT synthesis was investigated in a human cell line, HeLa-S, derived initially from a cervical carcinoma. Cells were grown in a serum free medium containing $1.5 \times 10^{-6} \text{M}$ Zn^{++} . Confluent cells were labeled with $^{65}\text{ZnCl}_2$, $^{109}\text{CdCl}_2$, or ^{35}S -cystine + Zn acetate ($5 \times 10^{-5} \text{M}$) and CdCl_2 (10^{-8} - 10^{-5}M) for 18-24 hours. Soluble proteins were chromatographed on a Sephadex G-75 column. Up to 4.7 nmol Cd^{++}/mg total protein was found associated with MT. Concentrations of 10^{-6} and 10^{-5}M Cd^{++} stimulated the incorporation of ^{35}S -cystine into MT. Addition of $5 \times 10^{-5} \text{M}$ Zn^{++} produced 3.6 nmol of Zn^{++}/mg protein in MT and stimulated the incorporation of ^{35}S -cystine. That cyclohexamide did not completely inhibit ^{109}Cd binding indicates that MT is normally present in the cell line. The results indicate that the induction of MT synthesis by Cd^{++} and Zn^{++} is not limited only to cells originating from the liver.

49. Rudd, C.J. and Herschman, H.R.: Metallothionein Accumulation in Response to Cadmium in a Clonal Rat Liver Cell Line. Toxicol. Appl. Pharmacol. 44:511-521 (1978).

RLC cells, a clonal line of cells derived from rat liver, accumulate ^{109}Cd in a unique bound form in response to exposure to Cd^{2+} . Cadmium administration also causes increased incorporation of $[^{35}\text{S}]\text{cystine}$ into a chromatographically distinct macromolecule. The ^{109}Cd -binding activity and the macromolecule preferentially labeled by $[^{35}\text{S}]\text{cystine}$ cochromatograph both on gel filtration and ion exchange columns. In addition, the Cd^{2+} responsive $[^3\text{H}]\text{cystine}$ -labeled moiety of RLC cells cochromatographs in both systems with rat liver $[^{35}\text{S}]\text{cystine}$ metallothionein labeled in response to Cd^{2+} challenge in vivo. These data suggest that RLC cells are able to accumulate authentic metallothionein in culture in response to Cd^{2+} challenge. Time course and concentration data for metallothionein accumulation and labeling with ^{109}Cd and $[^{35}\text{S}]\text{cystine}$ are presented. RLC cells in culture appear to be able to accumulate Cd^{2+} into metallothionein at a rate comparable to rat liver tissue in vivo when both systems are maximally activated.

50. Rudd, C.J. and Herschman, H.R.: The Response of HeLa Cells to Cadmium and Zinc. Toxicol. Appl. Pharmacol. 47:273-278 (1979).

HeLa cells, derived from a human cervical carcinoma, are able to accumulate cadmium in culture. The majority of the Cd^{2+} is bound to a protein identified as metallothionein (MT) by its elution volume on a Sephadex G-75 column ($V_e/V_0 = 1.8$). Increased amounts of Cd^{2+} are found in MT as the concentration of extracellular Cd^{2+} is raised from 10^{-8}M to 10^{-5}M . HeLa cells also incorporate labeled cystine into MT in response to Cd^{2+} . The HeLaCdMT separates into two major forms on DEAE ion-exchange chromatography. HeLa cells also bind ^{65}Zn to MT and incorporate labeled cystine into MT when exposed to $5 \times 10^{-5}\text{M Zn}^{2+}$. Maximal MT synthesis in HeLa cells in response to Zn^{2+} is as great as that observed in response to Cd^{2+} . Cycloheximide inhibits incorporation of labeled cystine into MT, as well as a large percentage of the binding of ^{109}Cd and ^{65}Zn to MT. Our data suggest that the potential to synthesize MT is not limited to cells derived from organs known to accumulate Cd^{2+} and Zn^{2+} , such as the liver, kidney, and intestine.

51. Sevanian, A., Mead, J.F. and Stein, R.A.: Epoxides as Products of Lipid Autoxidation in Rat Lungs. Lipids 14:634-643 (1979).

The nature and content of lipid epoxides in rat lung were examined. In addition, the levels of epoxides in air-breathing control rats and those exposed to nitrogen dioxide were compared. Exposure to 6-5 ppm for 24 hours resulted in significantly greater epoxide content in a number of lipid classes. It is proposed that lipid autoxidation in lung tissues may contribute greatly to the levels of epoxide-containing lipids. Furthermore, the processes involved in epoxide formation may be predicted from autoxidation studies utilizing unsaturated fatty acid monolayers

on silica gel which serves as a model for biomembranes. The findings indicate that exposure to oxidizing gases can lead to an accumulation of lipid epoxides in both lung parenchymal tissue and on the alveolar surface.

52. Sevanian, A., Stein, R.A. and Mead, J.F.: Formation and Metabolism of Cholesterol Epoxide in Rat Lung. Am. Rev. of Respiratory Diseases 119:358 (1979).

Recent evidence indicates that lipid autoxidation in membranes may result in epoxides as major isolable products. The processes responsible for epoxide formation appear to be particularly prevalent in the tissue and airspace of lungs. This is well exemplified by the levels of cholesterol 5,6 epoxides (CE) recovered from the lungs, liver and serum of male Sprague-Dawley rats. The respective amounts from these sources were measured as being 5.0 and 1.2 $\mu\text{g/g}$. tissue and 2.7 $\mu\text{g/dL}$. Exposure to 6 ppm NO_2 for 24 hrs. significantly increases lipid epoxide content in lungs, being for CE 7.8 $\mu\text{g/g}$. tissue. No significant increases were found in liver or serum. CE metabolism in lung homogenate preparations indicated that elimination was largely via hydration by microsomal epoxide hydrase(s) and to a minor extent by glutathione S-epoxides transferase. Hydration to the steroid triol was remarkably slower than hydration rates for fatty acid epoxides or those reported for other epoxides. Furthermore, earlier studies demonstrated no increases in cholesterol epoxide hydrase activity following exposure to NO_2 . Low epoxide hydase activity may be a consequence of the structural features of the oxirane group of CE and could contribute to epoxide accumulation in lung tissue. There is also evidence demonstrating carcinogenicity of CE. Such findings suggest that lipid autoxidation could lead to accumulation of potential carcinogens and may contribute to the hazards associated with oxidant inhalation.

53. Strong, D.D. and Herschman, H.R.: Identification and Characterization of a Brain-Specific Antigen Enriched in Neonatal Brain: II. Antigenic Stability, Species Cross-reactivity and Tumor Cell Association. Brain Res., in press (1979).

NABSA is a brain-specific antigen enriched in neonatal brain. Micro-complement fixation was used to determine the extent of serological stability of NABSA towards heat denaturation and freeze-thaw denaturation. NABSA antigenic activity was progressively lost from neonatal and adult brain solutions incubated at temperatures above 40° . All activity was lost above 65° . Dilute solutions of NABSA were stable at 8° for at least two weeks and could be frozen and thawed in tris-phosphate buffer at concentrations above 2 mg/ml with little loss of activity.

NABSA was found in every vertebrate species tested. An unusually close structural similarity (a frequent characteristic of both brain-specific antigens and fetal antigens) was demonstrated by serological methods among the mammalian and avian NABSA's.

NABSA was detected by microcomplement fixation analysis in four out of sixteen rat and murine neural clonal tumor cell lines. There was no clear limitation of NABSA to a particular class of neural cell (as defined by the phenotypes of these tumor cell classes) or to rapidly dividing or stationary phase cells. NABSA may be a brain-specific oncofetal antigen (DFA-Associated), since it is present in tumor cells of the nervous system and high levels are found in immature brain.

54. Takemoto, L.J. and Hays, E.F.: Cell Surface Proteins of Normal and Malignant Human Leukocytes: Homology With Envelope Proteins of Mammalian, C-Type Retroviruses. Blood 52(1):658 (1978).

Numerous studies of human tissue have reported conflicting results concerning the presence of structural components related to C-type retroviruses. To biochemically characterize such components, cell surface proteins of peripheral blood leukocytes from normal human donors were radioiodinated and extracted with 0.5% NP-40 detergent. These extracts were treated with antisera to feline RD114 virus, gibbon ape leukemia virus, and baboon endogeneous virus, followed by immunoadsorption with formaldehyde-fixed *Staphylococcus aureus*. Analysis by sodium dodecyl sulfate-polyacrylamide gel electrophoresis demonstrated the specific immunoadsorption of radioiodinated proteins of apparent molecular weight of 70,000 and 85,000 daltons. These antisera also immunoadsorbed cell surface components of similar molecular weight from peripheral blood leukocytes of leukemic patients and from leukocytes of established human cell lines of leukemic origin. Mapping of the radioiodinated tryptic peptides indicated the 70,000 and 85,000 dalton components contained peptides in common with gp70 of feline and primate retroviruses. Together, these results demonstrate that normal and leukemic human leukocytes possess cell surface proteins with antigenic, size, and amino acid sequence homology to the gp70 of other mammalian species.

55. Takemoto, L.J. and Hays, E.F.: Changes in Cell Surface Glycoprotein gp70, During AKR Thymic Lymphoma. J. Supramolecular Structure (3):328, abstract (1979).

Substantial evidence indicates that amino acid changes in the envelope glycoprotein (gp70) may determine the leukemogenic activity of C-type, murine retroviruses. It is therefore highly possible that viral infection and subsequent expression of an aberrant, cell surface gp70 may accompany the formation of various murine leukemias such as the spontaneous thymic lymphoma of AKR mice. To test this hypothesis, cell surface proteins of

thymocytes from normal and spontaneously leukemic AKR mice were radioiodinated, followed by immunoabsorption and tryptic peptide mapping of gp70. Thymocytes from normal AKR mice of 3.5-11.0 months of age possessed similar cell surface peptides of gp70. These peptides could all be assigned to the gp70 of either the AKR ecotropic or xenotropic virus. In contrast, gp70 peptides of cells from many spontaneous thymic lymphomas exhibited variable patterns including the presence of at least two gp70 peptides that could not be assigned to either the ecotropic or xenotropic virus. These results therefore demonstrate the presence of aberrant peptides of gp70 on the cell surfaces of thymocytes from AKR spontaneous lymphomas.

56. Villeponteaux, B., Lasky, L. and Harary, I.: Lysine-Rich Histones and the Selective Digestion of the Globin Gene in Avian Red Blood Cells. Biochemistry 17:5532 (1978).

Deoxyribonuclease I (DNase I) is known to preferentially digest the adult globin gene sequences in avian red blood cells. We have investigated the contribution of histones H1 and H5 in maintaining the nuclease-sensitive structure about the globin genes. When the lysine-rich histones H1 and H5 were selectively removed from avian red blood cell nuclei, the rate of digestion with DNase I increased several fold. However, the globin genes in H1- and H5-depleted nuclei were still selectively digested. Since histone H1 is necessary for the higher order folding of the nucleosomes, these data suggest that DNase I recognizes an aspect of structural heterogeneity within each core particle rather than some higher order packaging of the nucleosome cores.

57. Ward, J.F.: Radiation Damage to DNA in Aqueous Solution: Effects of Radiosensitizers. Br. J. Cancer 37(3):42 (1978).

Systems are described for examining the molecular mode of action of anoxic radiosensitizers with DNA-OH[•] radicals. Pulse radiolysis showed that NPPN reacts with these radicals even in the presence of 0.5 mm oxygen. Analysis of low molecular weight products liberated from DNA by irradiation showed that NPPN does not act in an oxygen-like way but that misonidazole does. Thus a molecular rationale exists for the use of combinations of radiosensitizers.

58. Ward, J.F. and Kuo, I.: Radiation Damage to DNA in Aqueous Solution: A Comparison of the Response of the Single-Stranded Form with That of the Double-Stranded Form. Radiat. Res. 75:2780285 (1978).

A comparison is made of the responses to radiation in aqueous solution of single-stranded and double-stranded DNA. Three types of experiments were performed: (1) pulse radiolysis observations of the DNA-OH[•]

transient, (2) measurement of neutral and alkali induced strand breaks, and (3) assays of low molecular weight fragments of thymine released from the macromolecule. The results showed a marked effect of macromolecular structure on radiation response. A working hypothesis is developed that the nucleic acid bases are protected inside the double helix against the reactions of OH $\cdot$ free radicals. Thus native DNA does not respond as a mixture of mononucleotides. Thus care should be taken to use low radiation doses when studying radiation damage to DNA, large doses breaking down the macromolecular into a form which does not respond to radiation similarly to native DNA.

59. Ward, J.F. and Lewis, H.L.: On the Mechanism of 5-Bromouracil Radiosensitization. Radiat. Res. 74:516 (1978).

In previous work (Zimbrick, Ward and Myers, Int. J. Radiat. Biol., 16, 505-34, 1969) we showed that 5 bromouracil (BU) reacts with hydrated electrons by dissociative electron attachment producing a bromide ion and a reactive uracilyl radical. The consequences of this reaction occurring in DNA were hypothesized to be formation of a uracil moiety and a strand break (by hydrogen atom abstraction from a neighboring deoxyribose moiety). We have tested these hypotheses: BU substituted DNA was gamma irradiated in aqueous solution under conditions where hydrated electrons are the only species reaction with DNA (absence of oxygen 0.1 M t-butanol). The production of strand breaks and of uracil was assayed. Strand breaks (alkali and neutral) could not be detected ($G < 0.01$) but uracil was measurable in significant yields ($G > 0.2$) using a serologic assay. In the uv photolysis of Bu DNA t-butanol also affects the yields of strand breaks preferentially reducing the alkali labile bonds produced. Thus the absence of strand breaks in ionizing radiation damaged DNA could be due to the presence of t-butanol

60. Wu, G.-S., Stein, R.A. and Mead, J.F.: Autoxidation of Fatty Acid Monolayers Adsorbed on Silica Gel. III. Effects of Saturated Fatty Acids and Cholesterol. Lipids 13:517-524 (1978).

Autoxidation of fatty acid monolayers on silica consisting of multiple components to simulate biomembranes has been studied by the rate of fatty acid disappearance and the products formed. When palmitic acid was incorporated into linoleic acid monolayers, the decrease in rate was proportional to the amounts of palmitic acid present. The protective effect of the saturated fatty acid diminished rapidly as the chain length of the saturated fatty acid decreased below C₁₂. With acids of medium chain length, C₁₂ was more effective than C₁₆. In pure linoleic acid monolayers, when the surface coverage was reduced to only 5% of the available adsorption sites, and in the case of palmitic acid-linoleic acid monolayers, the rate dropped drastically and the

major identified product formed was hydroxyepoxyoctadecenoic acid. On the contrary, the major product formed in the case of saturated monolayers of pure linoleic acid was mixture of unsubstituted epoxy acids. The inclusion of cholesterol in linoleic acid monolayers increased the rate of disappearance of linoleic acid slightly, whereas cholesteryl acetate decreased the rate. The protective effect exerted by cholesteryl acetate appeared to be similar to that of palmitic acid.

61. Wu, G.-S., Stein, R.A. and Mead, J.F.: Autoxidation of Fatty Acid Monolayers Adsorbed on Silica Gel. IV. Effects of Antioxidants. Lipids 14:644-650 (1979).

Inclusion of α - or γ -tocopherol in linoleic acid monolayers deposited on a silica gel surface introduced a definite induction period before the initiation of rapid autoxidation, as measured by the disappearance of linoleic acid. The length of the induction period was found to be proportional to the amounts of tocopherol incorporated at the concentration range tested and the protection was generally efficient with little loss of linoleic acid autoxidation. At the onset of the rapid autoxidation approximately 12% of the tocopherol remained, and most of this was destroyed after an additional short period. γ -Tocopherol, at the same concentration, was found to be 1.4 times as effective as the α -isomer. 3-(ω -Carboxynonyl)-4-methoxy-5-pentylphenol, the synthesis of which is described here, did not introduce a detectable induction period, but rather reduced the overall rate of autoxidation throughout a very long period.

DIVISION OF ENVIRONMENTAL BIOLOGY

RESEARCH HIGHLIGHTS

- Lead laboratory capability was established and implemented for studies concerned with the environmental effects of solar thermal power systems (STPS). Base-line studies were completed for the 10 MW pilot STPS electric plant located near Barstow, California. A comprehensive assessment of STPS worker health and safety concerns was completed. Position papers were prepared focusing on water resources, institutional constraints and air pollutant issues.
- Salinity effects, heat exchange, water dynamics and other environmental influences on photosynthesis in desert plants, including endangered species, have been characterized. The theory of trace element toxicity in plants has been further delineated to incorporate the efforts of multiple element toxicity. Additional knowledge has been developed concerning the role of elemental deficiencies and other nutritional stresses in arid areas on maintaining endemic native plant communities. Several new concepts for achieving revegetation cover on disturbed desert lands were tested and evaluated. The effect of water stress on the temperature dependence photosynthesis was determined for desert plants. A simulation model was developed and utilized to predict the northern range of cacti under various environmental conditions. The effects of precipitator ash from coal-fired power plants on desert plants and animals were studied. The influence of rainfall on breeding birds and soil arthropods in arid environments was characterized. Energy metabolism, food consumption, nutrient assimilation and water balances were assessed for lizards under field conditions using doubly labeled water. The status of the flat-tailed horned lizard was evaluated at prospective energy development sites in Southern California.
- A comprehensive review of the chemistry of Pu in soil and other geological materials was prepared. Pu-238, Pu-239, Am-241, Cm-244 and Np-237 were studied with respect to plant uptake and chemical extractability.
- A comprehensive environmental overview of geothermal development for the Mono-Long Valley KGRA was completed.
- An improved emission method of multi-element analysis of biological tissues was developed and applied which is capable of determining 29 elements common to biological tissues at the rate of 35,000 samples per year. A gamma scintillation technique that provides two dimensional viewing was developed for the study of the behavior of trace toxic metals and their chemical species in plant and soil systems.

ABSTRACTS

1. Badr, M., Wallace A. and El-Gazzar, A.M.: Effect of Soil Conditions and Botanical Characters on the Nutrient Level of the Leaves of Some Egyptian Flowers and Ornamental Plants. Alex. J. Agric. Res. 27:135-159 (1979).

Over 500 leaf samples representing over 100 different ornamental shrubs and trees and herbaceous floricultural plants were collected in 1976 and 1977. Five samples of about 100 g fresh weight each were collected from a given site with an appropriate soil sample of about 2 kg. The samples represented 40 annual and perennial flowering plants, 10 shrubs, 9 trees and 6 greenhouse plants. The major objective was to compare mineral composition, by botanical classification, (family, genus, species) with soil characteristics. Leaf samples after wiping and washing with water were analyzed for many elements by emission spectrography and N by chemical means. Soils were analyzed by standard methods for major characteristics. There were large differences among the plant species in mineral concentrations. There were also major differences within plant species. There were very few indications of possible B toxicity. Zinc deficiency was indicated in a few instances. Most nutrients for most plants appeared to be in the adequate range. Among the four groups of plants (flowers, shrubs, trees and greenhouse plants), composition did not vary for Cu, Fe, Mn and B. It did vary for N, P, Na, K, Ca, Mg and Zn. Several Na accumulators existed among the species. Leaf analyses were compared with soil analyses. Many of the soils were relatively saline. The soils also differed in texture, CaCO₃ and nutrient levels.

2. Berry, W.L., Krizek, D.T., Ormrod, D.P., McFarlane, J.C., Langhans, R.W. and Tibbits, T.W.: Nutrient Content of Lettuce Grown Under Specified Conditions in Six Controlled-Environment Facilities. J. of the Amer. Soc. of Hort. Sci., in press (1979).

Lettuce (*Lactuca sativa* L. 'Grand Rapids') plants were grown under specified conditions for 28 days in controlled-environment chambers. Four to five studies each of identical design were performed by five independent investigators at six locations. Plant tissue from all studies was collected and analyzed at one laboratory for 25 mineral elements by arc emission spectrography. These studies were designed to provide comparative information on the amount of variability in tissue nutrient composition of plants grown under specified controlled environment conditions within the same laboratory and in different laboratories. Analysis of lettuce plant tissue for ten of the essential elements indicated that they were found at concentrations considered in a satisfactory range for normal growth and development. The overall system variation for plant analysis was examined and was found to be quite large. Tissue analyses showed large differences in absolute tissue nutrient content

between experiments in the same laboratory as well as among different laboratories suggesting inadvertent contamination and/or addition of mineral elements from the rooting media, the water system and/or the local environment in each laboratory.

3. Berry, W.L., Ormrod, D.P., Hammer, P.A., McFarlane, J.C., Krizek, D.T., Langhans, R.W. and Tibbits, T.W.: Uniformity Studies With Lettuce: Results of Growth and Tissue Analysis. Phytotron News-Letter 19:62-66 (1979).

'Grand Rapids' lettuce (*Lactuca sativa* L.) was grown under baseline-type conditions for 28 days in controlled environment chambers. Multiple studies of identical design were performed by six independent investigators at seven locations. Growth parameters were followed weekly for four weeks and tissue nutrient composition determined at the fourth harvest. These studies document a rather large variation in growth and nutrient composition between studies within a laboratory even when growing procedures and environmental measurements were highly standardized. The variation in growth within laboratories was greater than the variation among laboratories. Thus to obtain an accurate estimate of experimental error multiple studies must be utilized rather than multiple plants within one chamber. The procedures developed can also be utilized as a bioassay to verify normal operation and environmental control in research facilities.

4. Berry, W.L. and Ulrich, A.: Interactions of Environmental Factors. In Proceedings Controlled Environments Working Conference, Tibbits, T.W. and Kozlowski, T. eds. (1979).

Many controlled-environment studies have been designed to very carefully control and monitor one or at most a few environmental factors while paying relatively little attention to others. It is becoming increasingly important, however, to carefully control a number of additional factors in order to assess the impact on plants of numerous interactions among such factors. Such interactions may be synergistic, additive, independent or antagonistic.

This paper discusses interactions among environmental factors and emphasizes interactions of mineral supply with water, temperature, air pollution, light intensity and nutritional preconditioning.

5. Berry, W.L., Wallace, A., Patel, P.M. and Lunt, O.R.: Further Development of the Use of Wastewater for Hydroponic Crop-Culture. Alex. J. Agric. Res. 24:189-198 (1979).

Reclaimed secondary-treated municipal wastewater from the Tapia reclamation plant of the Las Virgenes Municipal Water District in Los Angeles County, California was used to grow commercial horticultural crops.

The partitioning of trace elements among the wastewater, roots, stems and fruit was determined. The distribution within the plant in relation to the roots was such that Ca, Mg, K, Na and B were concentrated in the fruit while P and most of the trace elements were excluded to some degree from the fruit. For example, there was two times as much calcium in fruit as in the root, but 800 times less Mn in the fruit than in the root. In plants grown in this particular wastewater Co, Ni, Cd, Cr and Sn were not detected in the fruit, but were present in significant concentrations on and in the roots.

Flow rate studies were run at 4, 10 and 20 liter/min/bed of cucumbers over a 10-week period. The highest flow rate gave the highest yield of both plant material and fruit, but the two lower flow rates were not constantly lower. Tissue analysis did not indicate any nutrient deficiencies even at the lowest flow rate. It appears that even at the lower flow rate the mineral nutrients were not limiting, however, other physical parameters such as oxygen availability could become limiting before the mineral nutrients.

Previous greenhouse pot cultures had indicated that iron could be made available in wastewater with pH adjustment. This was tested in the pilot-size greenhouse at Tapia by lowering the pH of one of the beds from 7.6 to 6.2 with H_2SO_4 . The iron deficiency symptoms were eliminated, but the growth was not comparable to the controls; some abnormal symptoms remained. The plants had a general loose form showing symptoms similar to those of phosphate deficiency but in addition had interveinal necrotic areas on the old and mature leaves similar to those attributed to heavy metal toxicity by Hewitt (1948).

Although the pilot project demonstrated that commercial horticultural crops could be grown using municipal wastewater as the source of nutrients and water, the limits of many important cultural parameters have not yet been determined. In order to make the technique fully practical on a commercial scale while simultaneously improving the water quality, the following recommendations are suggested pending further study:

1. Do not use the green leafy parts of vegetable for food, rather use only fruit or similar structures.
2. If heavy metal removal from water is of concern, grow shortcycle crops such as cucumbers where plants and roots will be frequently discarded.
3. Boron is present in most wastewater at chronic toxicity levels, as it is in this district, and efforts should be made to reduce it nationwide through improvement of soaps and detergents.
4. Determine the contribution of particulate matter to the trace element burden of the effluent water and its relationship to the efficiency of trace element uptake by hydroponic crops; procedures may then be developed for decreasing the burden.

5. Determine the relationship of flow rate to nutrients removed by hydroponic crops.
 6. Determine the degree of trace element binding by the organic fraction of effluent water.
 7. Determine the effect of high salt on plant growth in flowing hydroponic systems since salt burden of the wastewater can vary.
6. Congdon, J.D., Ballinger, R.E. and Nagy, K.A.: Energetics, Temperature and Water Relations in Winter Aggregated Sceloporus Jarrovi (Sauria: Iguanidae). Ecology 60:30-35 (1979).

Metabolic rates and water fluxes in winter-aggregated Yarrow's spiny lizards (Sceloporus jarrovi) were measured in the field using doubly-labeled water. Resting metabolic rates were estimated from measurements of microhabitat and lizard body temperatures. During the month (November) following aggregation at the hibernaculum and the month (April) before dispersal, lizards were relatively active and their metabolic rates averaged $0.071 \text{ ml CO}_2 \cdot \text{g}^{-1} \cdot \text{h}^{-1}$, = 40% of their warm season rates. From December through March, lizards basked but were relatively inactive with metabolic rates averaging $0.031 \text{ ml CO}_2 \cdot \text{g}^{-1} \cdot \text{h}^{-1}$, = 15% of warm season rates. Water influx rates averaged $10.3 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{day}^{-1}$ during the 120-day inactive period. Water loss was slightly higher than gain and lizards lost weight slowly while hibernating, having ended the 6-mo aggregation period with a 22% decline in body mass. Total energy expenditures during the aggregation period averaged = 7.53 kJ, <½ of which could have been supplied by stored body fat. This, together with other direct and indirect evidence, suggests that lizards fed during the cold season. As a result of basking and displaying some activity, S. jarrovi spent >3 times as much energy during the aggregation period as would a lizard remaining inactive in a crevice at 10°C for the entire 6 mo. Possible benefits of winter basking are discussed.

7. El-Gazzar, A.M., Wallace, A. and Nawar, A.: Leaf Analysis of Citrus in Egypt. Alex. J. Agric. Res. 27:1-10 (1979).

A nutritional survey was carried out in 1976 to investigate the mineral status of five citrus varieties grown in eight different orchards representing different types of Egyptian soil. The different management practices and soil analysis were recorded and used for interpretation of the data. The results could be summarized as follows:

The level of the nutrient elements varied among the eight experimental orchards, suggesting the need for a separate leaf analysis and fertilization program for each orchard.

Phosphorous, potassium, calcium, magnesium, boron, copper, iron, sodium and chloride were found in adequate or in excessive amounts in the leaves of all the orchards. The nitrogen, manganese and zinc were found, in some of the orchards, in the deficient or low range.

The relative concentration of the different elements varied from one variety to the other. The Soucary orange leaves contained the highest level of nitrogen and calcium and were lowest in phosphorous, calcium, zinc and boron. The maximum concentration of iron was found in Valencia orange leaves, which also contained the minimum concentration of copper, sodium and chloride. Balady mandarin leaves possessed high values of magnesium, manganese, copper, zinc and boron and chloride and low values of iron. The leaves of Navel oranges contained the highest concentration of potassium and were lowest in magnesium.

The nutritional status of most of the orchards was influenced by the mechanical or chemical composition of the soil as well as by the cultural care usually practiced.

8. El-Ghonemy, A.A., Wallace, A. and Romney, E.M.: Nutrient Concentrations in the Natural Vegetation of the Mojave Desert. Soil Science 126:219-229 (1978).

The mineral composition of perennial plant species from widely separated sites in the Mojave Desert varied among sites, but variation between species was more pronounced. According to the nutritional status, species have been classified into different categories each of which includes species characteristically rich or poor in a given element. The close relationships between the nutritional status of these species and their sociological relations, as reflected by the principal component analyses, are evaluated. The frequency of correlation between the concentration of the different element pairs across the different species studied has been evaluated and discussed. Stress has been focused on Ca-Zn relations, with an 80 percent frequency of positive correlation. The causal factor or factors behind this high percentage of positive correlation frequency have been suggested. Linear correlation coefficients between plant composition and soil variables were also obtained.

9. Farnsworth, R.B., Romney, E.M. and Wallace, A.: Nitrogen Fixation by Microfloral-Higher Plant Associations in Arid to Semiarid Environments. In Nitrogen in Desert Ecosystems, Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pa., Chapter 2, pp. 17-19 (1978).

The most popularly recognized input of nitrogen into ecosystems is symbiotic fixation through bacteria on root nodules of legumes. Legumes, however, are not always a major component of desert plant communities (West and Klemmedson, Chapter 1 of this volume). Even when they are, most studies have shown that nodules are often lacking.

Other research has shown that nitrogen is definitely fixed in desert soils. Since free-fixing microbes are rare in arid environments, and blue-green algae in lichen soil crusts are not always present, nitrogen fixation must therefore take place in some kind of association with higher plants.

10. Franco, P.J., Edney, E.B. and McBrayer, J.F.: The Distribution and Abundance of Soil Arthropods in the Northern Mojave Desert. J. Arid Environments 2:137-149 (1979).

Arthropods were extracted from soil samples taken about the four major perennial plant species in Rock Valley, Nevada from January to December 1974. The majority of the animals collected belonged to the Acari (mites), the dominant groups including the fungivorous and detritivorous Oribatids and the Nanorchestids. The predatory Tydaeid mites were also quite abundant and indications are that these feed primarily on nematodes.

The distribution of soil arthropods is strongly influenced by the shrubs. The greatest densities of arthropods are found at the shrub bases and linearly decline with distance toward the plant canopy margin. Population levels in the large intershrub areas are minimal except during periods of favorable climatic conditions. Total arthropod densities ranged from 1600 per m² in July, when soil was the driest and temperatures were maximal, to 12,400 per m² in December after autumnal rains.

11. Hill, H.O.: Breeding Birds in a Desert Scrub Community in Southern Nevada. Southwest. Nat., in press (1979).

Breeding bird populations were studied in a creosotebush community of the northern Mojave Desert in Rock Valley, Nevada, between 1971 and 1973. Two species bred in the dry years (1971, 1972) and five species in the exceptionally wet year (1973). Larger clutches were laid in 1973. The paucity of breeding species was associated with a structurally simple desert community of low productivity. Densities of breeding pairs (46-80/100 ha) were intermediate to densities recorded in other desert scrub environments. The regular breeders--LeConte's Thrasher (Toxostoma lecontei) and Black-throated Sparrow (Amphispiza bilineata)--exhibited high breeding densities (3/100 ha and 43-61/100 ha, respectively) compared to other localities within their breeding range.

12. Lindberg, R.G.: An Overview of Solar Thermal Electric Systems, Environmental Issues. Proceedings of U.S. Department of Energy Environmental Control Symposium, in press (1978).

Attractive features of solar energy for production of electricity include an inexhaustible and virtually free energy source as well as very minimal impacts on air quality relative to conventional power plants.

The two major applications of STPS technologies are (1) large scale (300-500 MWe), centralized receiver systems and (2) smaller scale (0.5-10 MWe), dispersed receiver systems applicable for either or both electric power generation and heat production. Environmental concerns vary significantly with the application.

Large scale centralized STPS are land, water and capital intensive. Major environmental concerns derive from siting such facilities in southwestern deserts. The principal environmental concerns are for potentially irreversible ecological impacts in the vicinity of STPS sites, and worker safety on-site. The primary siting constraint will be availability of water.

Smaller scale, dispersed receiver, STPS are likely to be located near areas already developed for agriculture or industry. The primary environmental concern will be public safety and protection of property. The primary siting constraint will be institutional barriers associated with land use, zoning, utility interfaces, etc.

Representative areas requiring further assessment are handling and disposal of system fluids and wastes; consequences and mitigation of accidental releases of working fluids; consequences and mitigation of normal and misdirected heliostat reflection; possible alterations of local ecosystems and microclimates near heliostat fields; and socioeconomic and institutional constraints to adoption of STPS technology.

13. Longstreth, D.J. and Nobel, P.S.: Salinity Effects on Leaf Anatomy. Consequences for Photosynthesis. Plant Physiology 63:700-703 (1979).

Many desert soils have a high salinity, and salinity has been known to affect photosynthetic properties of leaves. Here, the reasons for salinity effects on the morphology and CO_2 exchange characteristics of leaves were analyzed using a resistance circuit analogy. Increasing salinity led to substantially higher ratios of mesophyll surface area to leaf area (A_{mes}/A) for Phaseolus vulgaris and Gossypium hirsutum and a smaller increase for Atriplex patula, a salt-tolerant species. The increase in internal surface for CO_2 absorption did not lead to higher CO_2 uptake rates, since the CO_2 resistance expressed on the basis of mesophyll cell wall area (r_{cell}) increased even more with salinity. The differences among species in the sensitivity of photosynthesis to salinity in part reflect the different A_{mes}/A and r_{cell} responses.

14. Nagy, K.A. and Milton, K.: Aspects of Dietary Quality, Nutrient Assimilation and Water Balance in Wild Howler Monkeys (Alouatta palliata). Oecologia 39:249-258 (1979).

Wild howler monkeys were fed natural fruit and leaf diets in order to determine their ability to assimilate minerals (Ca, P, Mg, Si, Sr, Ba,

Fe, Al, Mn, B, Cu, Li, V), and to assess their water and electrolyte budgets by the balance method. Results were extrapolated to the field situation so that the nutritional status of free-living monkeys could be examined in relation to their diet. The figs and young leaves of *Ficus insipida* and *F. yoponensis* trees (the most important foods in the dry season) provide adequate amounts of most required minerals, and an abundance of water. However, the copper requirement would not be met by this diet, which also provides only marginal amounts of sodium and phosphorus. These deficiencies may be corrected by consuming other available food items that are rich in Cu, Nd or P. These results help explain the diversity that has been observed in the diet of wild howler monkeys, and suggest that these herbivores should feed selectively in order to obtain a nutritionally adequate diet.

15. Nagy, K.A. and Milton, K.: Energy Metabolism and Food Consumption by Wild Howler Monkeys (*Alouatta Palliata*). *Ecology* 60:000-000 (1979).

Rates of CO₂ production in free-living and captive howler monkeys were measured using doubly labeled water, and assimilation of energy from natural foods was determined. Results permit construction of a field energy budget, and estimation of the feeding rate of these arboreal, plant-eating primates. Field metabolic rates averaged 355 kJ kg⁻¹ day⁻¹ (=2x basal metabolic rate). Assimilation of the energy in a fruit and leaf diet was =40%. Feeding rate in the field is estimated to be =54 g dry matter kg⁻¹ day⁻¹, or =90 kg dry matter ha⁻¹ yr⁻¹.

16. Nishita, H. and Haug, R.M.: Effect of Fulvic and Humic Acids and Inorganic Phase of Soil on the Sorption and Extractability of ²³⁹Pu(IV) UCLA 12-1181, UC-48, U.S. Department of Energy (1979).

The effect of organic (fulvic and humic acids) and inorganic fractions of soil on the sorption and extractability of ²³⁹Pu(IV) as a function of pH was determined by using an equilibrium batch technique. The results indicated that Pu(IV) is strongly sorbed on the inorganic fraction of the soil under soil pH conditions normally encountered in natural environments. Plutonium appeared to form stable complexes or chelates with fulvic and humic acids in the pH range (pH 1.3 - 11.7) studied. In mixtures of pure fulvic or humic acids with soil inorganic fractions, the extractability of Pu was substantially influenced by organic-inorganic interaction. The influence of the inorganic fractions was most evident in the lower pH ranges, whereas that of the organic materials was most evident in the higher pH ranges, generally above pH 6. Some implications of the results on Pu movement in soils were discussed.

17. Nishita, H. and Haug, R.M.: Some Factors That Influence the Extractability of $^{239}\text{Pu}(\text{IV})$ From Several Clay Minerals. UCLA 12-1183, UC-48, U.S. Department of Energy (1979).

The effect of clay minerals on the extractability of $^{239}\text{Pu}(\text{IV})$ was determined by using an equilibrium batch technique. The $<2\ \mu\text{m}$ size fraction of three American Petroleum Institute reference clay minerals (montmorillonite No. 26, kaolinite No. 3, and illite No. 35) were used. The extractability of Pu from clay suspensions prepared on equal weight basis differed to some extent from those prepared on equal equivalency basis. The Pu extractability also depended on clay/solution ratio, clay mineral type, clay particle size distribution, NO_3^- concentration, and pH.

18. Nishita, H., Wallace, A. and Romney, E.M.: Radionuclide Uptake by Plants. NUREG/CR-0336, UCLA 12-1158, U.S. Nuclear Regulatory Commission (1978).

Natural radionuclides are always present in the environment and, together with those made by man in the past thirty or more years, differentially move through geochemical and biological cycles. The general principles governing the uptake, transport and redistribution in plants of radionuclides are reviewed. Also plant uptake of selected radioisotopes of U, Ra, Th, Sr, I, Cs, Tc, Np, Pu, Am and Cm are discussed in some detail. These isotopes were selected because of their potential usefulness or harmfulness to man in nuclear power generation and in other contexts.

19. Nobel, P.S.: Leaf Anatomy and Water-Use Efficiency. In Adaption of Plants to Water and High Temperature Stress, Turner, N.C. and Kramer, P.J. eds., Wiley-Interscience, New York, in press (1979).

The effects of various environmental factors such as illumination, temperature, soil water potential, salinity and nutrients on mesophyll surface area per unit leaf area (A_{mes}/A) and water-use efficiency (mass of CO_2 fixed in photosynthesis/mass of water lost in transpiration) were critically reviewed for a binational (Australian and U.S.) held at Stanford University in November 1979. Recent results of our laboratory were presented. It was shown that the responses to water stress and salinity were mainly stomatal as far as the water-use efficiency was concerned. Enhancements in water-use efficiency as the growth illumination was increased were shown to reflect the increased CO_2 uptake due to the greater A_{mes}/A . Nutrient effects were primarily at the cellular level, while temperature had extremely varied and complicated effects. The significance of enhanced water-use efficiency caused by increased A_{mes}/A for agronomic practice was emphasized.

20. Nobel, P.S.: Surface Temperature of Cacti - Influences of Environmental and Morphological Factors. Ecology 59:986-996 (1978).

An energy budget model predicted the average stem surface temperatures of a Mammillaria dioica 9.4 cm tall and a Carnegiea gigantea 5.64 m tall within 1°C of the hourly measured temperatures over 24-h periods. For the ranges of various environmental factors considered in a sensitivity analysis, the average surface temperature of the stem was most influenced by air temperature. Greater diurnal extremes of stem temperature occurred at lower wind velocities. Asymmetrical heating of the stem by direct solar irradiation was clearly evident in the measurements and the simulations.

The model was used to study the effect of morphological changes on stem surface temperatures. For example, in the absence of spines the average surface temperature of Mammillaria became 1 to 2°C cooler at night and 2 to 6°C warmer during the day. The effect of spines on the simulated diurnal temperature variation was even greater for the apical meristem, which had the most dense coverage of spines. Simulations under the same environmental conditions showed that lower stem and apical temperatures occurred for Carnegiea, consistent with its restriction to lower (presumably warmer) elevations than Mammillaria.

21. Nobel, P.S. and Hartsock, T.L.: Environmental Influences on Open Stomates of a Crassulacean Acid Metabolism Plant, Agave deserti. Plant Physiology 63:63-66 (1979).

Succulent plants are characteristic of the desert and many of them are on threatened or endangered species lists for the southwest. Even though the development of energy technologies has focused extra attention on the utilization of desert resources, the desert still remains one of the least examined major ecosystems. The objective here was to determine the environmental influences on the stomates of a common succulent in the Sonoran desert.

The major short term stomatal response of Agave deserti was to temperature; increases in leaf temperature led to decreases in water vapor conductance for stomatal opening during the daytime (C₃ mode) as well as at night (Crassulacean acid metabolism or CAM mode). Hourly changes in the water vapor concentration drop from leaf to air had no significant stomatal effect in either mode. Stomatal responses to external CO₂ levels up to 800 microliters per liter were not significant after 15 minutes and only moderate after a few hours, suggesting that CO₂ effects on open stomates of this succulent were indirect in both CAM and C₃ modes.

22. Nobel, P.S., Longstreth, D.J. and Hartsock, T.L.: Effect of Water Stress on the Temperature Optima of Net CO₂ Exchange for Two Desert Species. Physiologia Plantarum 44:97-101 (1978).

The temperature dependence of photosynthesis was determined at various soil water potentials for two sympatric desert species, Notholaena parryi D.C. Eat. (Pteridaceae) and Encelia farinosa Gray (Compositae). As water stress increased, the temperature optimum of photosynthesis shifted 7 to 10°C downward and the maximum rate decreased for both species. The downward shift in temperature optimum with water stress was the result of a greater fractional stomatal closure with increasing temperature and a lowering of the temperature where maximal CO₂ residual conductance appears to reflect (1) a greater effect of water stress on gross photosynthesis than on respiration plus photorespiration and (2) the higher temperature optimum for respiration plus photorespiration than for gross photosynthesis. The downward shift in the temperature optimum of apparent photosynthesis can have a significant effect on the predicted carbon balance of plants as the soil water potential decreases.

23. Pearson, A.K., Licht, P., Nagy, K.A. and Medica, P.A.: Endocrine Function and Reproductive Impairment in an Irradiated Population of the Lizard Uta stansburiana. Radiation Research 76:610-623 (1978).

This study describes gonadal changes in lizards (Uta stansburiana) exposed to chronic low levels of γ radiation (1.5-10 R/day) under field conditions and attempts to evaluate endocrine involvement in these changes. Reproductive impairment in irradiated males is demonstrated during the breeding season by reduced testes weights and by seminiferous tubules devoid of germ cells. Ultrastructural morphology of Leydig cells, plasma testosterone levels and developed accessory sex structures indicate normal steroidogenesis in such males. Cytology of the pituitary gonadotropes and pituitary gonadotropin content indicate normal gonadotropin levels. These findings suggest that low levels of radiation affect the spermatogenic process directly, rather than through damage to the pituitary. Comparable irradiation causes complete resorption of ovarian tissue in some female Uta. The oviducts are atrophic and the pituitary gonadotropes hyperactive. Resemblance of gonadotropes to those of castrated animals and reduced pituitary hormone content suggest elevated levels of gonadotropin production, probably due to the absence of ovarian steroid feedback in affected animals. The continued mitotic activity of oogonia in adult reptiles and their limited number contribute to the vulnerability of germinal tissue in irradiated female lizards. Destruction of the germ cell is accompanied by resorption of all ovarian tissue including steroidogenic elements. Thus, in females as in males, radiation appears to damage gametogenesis rather than pituitary function.

24. Procopiou, J. and Wallace, A.: A Nutritional Disorder in Pistachio from Near Athens, Greece. Commun. Soil Sci. Plant Anal. 9:931-934 (1978).

A problem pistachio orchard near Athens, Greece had many trees with severely scorched leaves. Half or more of each leaflet was brown and dry but tips and edges were most affected. Affected leaves were also of lighter green color than normal leaves and slightly resembled Fe deficiency. Leaf analysis indicated low K, low Fe, and high Mg. Irrigation water contained moderate levels of Mg and Na chlorides and chloride toxicity was possibly another factor. Improvement was observed when Fe chelate was applied to the orchard but Mg-induced K deficiency was possibly a major factor. Response to K applied to soil was not observed after four months, however.

25. Procopiou, J. and Wallace, A.: Effects of Arsenic Sprays on Different Citrus Fruit Juice Acidity. Alex. J. Agric. Res. 27:93-98 (1979).

Summer sprays of some arsenic compounds were tried on some citrus varieties at the University of California, Los Angeles (UCLA) to determine if acid concentration of fruit could be reduced. Potassium arsenate, sodium arsenite, and arsenic trioxide were effective in lowering citrus fruit acidity during the short period of study. Lead and calcium arsenate were effective only in some cases at their higher concentrations. Associated leaf fall from the sprays may have reduced fruit size.

26. Procopiou, J. and Wallace, A.: Leaf Mineral Concentration of Some Citrus Scions on Different Rootstocks and Citrus Seedlings Grown in Greece. Alex. J. Agric. Res. 27:67-77 (1979).

The leaf mineral element concentration of some citrus varieties on several different rootstocks introduced in 1964 and used experimentally thereafter in Greece is presented. The analysis showed that scion leaves grown in a collection on Rhodes, Greece may be low in K, Zn, Cu and Mn. Clementine had lowest P (0.110%) on sour orange rootstock as compared to Clementine on rough lemon, Troyer citrange and Carrizo citranges, Citrus moi, Citrus volkameriana Pasq., and Rangpur lime. Frost Washington navel orange had the highest P (0.220%) on Cleopatra mandarin as compared on Palestine sweet lime, Citrus taiwanica, Rangpur lime, C. moi, Troyer citrange, and rough lemon rootstocks. The Ca and Mg may be normal to high and P, Na, Fe, and B appear normal. Leaf analysis data of Washington navel orange on some rootstocks from the coldest and probably most waterlogged citrus area (ARTA) of Greece are also presented. They appear to be somewhat low in P on sour orange and Rangpur lime rootstocks, low in Mn on the citrange rootstocks, normal to low in Fe and B for some and normal to high in both K and Mg and Rangpur lime rootstocks. Rootstock seedlings grown

on Rhodes and also some in Arta and Crete are presented. The results indicate that some may be low in leaf Zn and probably in Cu, Mn, and B. Poncirus trifoliata, the citranges and the Kumquat (which is not used as a rootstock) were low in K. Although with chlorotic foliage, P. trifoliata leaves had the same Fe concentration as the nonchlorotic rootstocks.

27. Procopiou, J. and Wallace, A.: Mineral Element Concentration of Leaves of 23 Varieties of Olive. Alex. J. Agric. Res. 27:51-54 (1979).

The leaf concentration of 15 mineral elements for 23 olive varieties (Olea europea L.) in Rhodes, Greece was determined by emission spectrography. The mineral elements were P, Na, K, Ca, Mg, Zn, Cu, Fe, Mn, B, Al, Si, Sr, Ba, and Li. Differences in mineral concentration were found among varieties. Seven varieties showed less than 0.1% P, 20 less than 1% K, 11 less than 20% Ca and all varieties showed relatively low Zn. All but one variety had less than 19 µg B/g plant material. Possible stresses in these varieties for at least some of these elements may be indicated.

28. Procopiou, J., Wallace, A. and Romney, E.M.: Mineral Element Concentration in Leaves of Some Citrus Varieties Grown in Greece. Alex. J. Agric. Res. 27:79-86 (1979).

Leaf concentrations of 16 mineral elements were determined for several citrus varieties grown in trials or commercially in Greece. Those in trials were from a collection on Rhodes of 20 varieties, most of which are new to Greece being introduced from California in 1964. Analysis of about 8-month-old leaves sampled in December 1976 shows that for many varieties K and Zn may be marginal to low and in some, Mn, B and Cu may also be somewhat low. Leaves were normal in P, Fe and Ca while Mg was generally normal, but in some cases high. Although tissue analysis indicated high Mg, visual deficiency symptoms are sometimes found in and around the collection orchard. A leaf analysis survey of selected growing areas in Greece indicated Fe deficiency in lemon trees in Corinth and mild Mg, Zn, Fe and Mn deficiencies in other areas. The tissue analysis generally verified visual diagnosis of tree condition.

29. Rehab, F.I. and Wallace, A.: Excess Trace Metal Effects on Cotton: 4. Chromium and Lithium in Yolo Loam Soil. Commun. Soil Sci. Plant Anal. 9:645-651 (1978).

Two cultivars of cotton (Gossypium spp) were grown in Yolo loam soil in a glasshouse to determine phytotoxicity effects of Cr and Li and possible interactions with other metals. The Cr at 100 µg/g soil had no adverse effects on either cultivar studied. A Cr increase

was not observed in either stems or leaves. Both cultivars tolerated 25 and 50 $\mu\text{g Li/g soil}$. The 50 $\mu\text{g Li/g soil}$ resulted in leaves of Acala SJ-2 with 432 $\mu\text{g Li/g leaves}$ and 720 in Giza 45. The 100 $\mu\text{g Li/g soil}$ resulted in 74% and 87% leaf yield reductions in Acala SJ-2 and Giza 45 respectively. Leaf concentrations of Li respectively were 1950 and 1850 $\mu\text{g/g}$. Except at the highest level of Li, leaves had higher concentrations of Li than did roots. The Cr and Li resulted in some plant metal interactions.

30. Rehab, F.I. and Wallace, A.: Excess Trace Metal Effects on Cotton: 5. Nickel and Cadmium in Solution Culture. Commun. Soil Sci. Plant Anal. 9:771-778 (1978).

Two cultivars of cotton (*Gossypium* spp.) were grown in solution culture in a glasshouse to determine phytotoxicity effects of excesses of Ni and Cd. Leaf yield was depressed 94% by 10^{-4}M NiSO_4 (with 198 $\mu\text{g Ni/g leaf}$) in Acala SJ-2 and 93% (with 167 $\mu\text{g Ni/g}$) in Pima PS-5. The Ni gradient was roots > stems > leaves in both cultivars. At 10^{-5}M , CdSO_4 gave more phytotoxicity than NiSO_4 . The 10^{-4}M CdSO_4 resulted in about the same amount of phytotoxicity as did the Ni for both cultivars. The Pima PS-5 plant parts, however, contained less Cd than did the Acala SJ-2 at the highest Cd concentration. At 10^{-5}M CdSO_4 the reverse held in leaves and stems. Interactions held for both metals but the inverse effect between Cd and Mn was less pronounced than for other species. Many other interactions were present.

31. Rehab, F.I. and Wallace, A.: Excess Trace Metal Effects on Cotton: 6. Nickel and Cadmium in Yolo Loam Soil. Commun. Soil Sci. Plant Anal. 9:779-784 (1978).

Two cultivars of cotton (*Gossypium* spp.) were grown in Yolo loam soil in a glasshouse to determine phytotoxicity effects of excesses of Ni and Cd. A 200 $\mu\text{g/g}$ level of Ni in soil reduced yield by 60% in Acala SJ-2 and by 83% in Giza 45. The leaf Ni concentrations, respectively, were 146 and 165 $\mu\text{g/g}$. The 300 $\mu\text{g/g}$ level of Cd decreased leaf yields by 60% and 75% for the two cultivars, respectively. Leaf concentrations of Cd, respectively, were 43 and 63 $\mu\text{g/g}$. There was a stem to leaf gradient of Cd for all cases. High Cd did not depress Mn concentrations in plants as in other species but there were many mineral element interactions.

32. Rehab, F.I. and Wallace, A.: Phosphorus Levels and Soil pH on Phosphorus and Micronutrient Status of Cotton Grown in Soil in a Glasshouse. Alex. J. Agric. Res. 27:177-180 (1979).

Two cultivars of cotton (*Gossypium* spp.) were grown for 4 weeks in calcareous Hacienda loam soil in pots in a glasshouse with added 0, 100, and 500 $\mu\text{g P/g soil}$. Both cultivars responded favorably to the

100 µg P/g soil but only the Acala SJ-2 responded additionally to the 500 µg/g. The Acala SJ-2 cultivar appeared to accumulate less P in leaves than Giza 70 but also to more effectively utilize that present. Leaf critical level of P appeared to be around 0.18 % P. The high P decreased leaf concentrations of Zn perhaps to the deficiency level. There were interactions with several other trace metals. In other experiments the P-Zn interaction was related to soil pH and interactions among other trace metals tended to modify that between P and Zn. The Mo concentration was also decreased by P in one experiment.

33. Rehab, F.I. and Wallace, A.: Sodium Chloride on Growth, Mineral Composition and Gas Exchange Characteristics of Three Cultivars of Cotton Grown in Soil in a Glasshouse. Alex. J. Agric. Res. 27:237-245 (1979).

Three cultivars of cotton (*Gossypium hirsutum* L. cv. Acala SJ-2 and *G. barbadense* L. cv. Pima PS-5 and cv. Giza 45) were grown for 68 days in 2 kg quantities Yolo loam soil (Typic Xerorthents, fine silty, mixed thermic) in a glasshouse with different levels of NaCl added to the soil (equivalent to about 1, 5, 10 mmho/cm in the saturation extract). The objective was to determine comparative responses of the three cultivars to moderate amounts of salt in terms of growth, mineral nutrition, net photosynthesis and transpiration. Although yield differences were not great, the Pima PS-5 was more affected by salt than the other two cultivars and the Acala SJ-2 was the least affected. Square yields of Pima PS-5 were greater than for the other cultivars. Pima PS-5 was the least salt tolerant but it did have the highest yields in the controls. Acala SJ-2 had lowest K concentration in leaves. There were no cultivar differences in Cl or Na concentrations. The salt did not decrease net photosynthesis or transpiration in any variety indicating complete adjustment and compensation. Since yields were decreased slightly by at least the high level of salt used, it must be for reasons other than photosynthesis and transpiration or plant nutrition except possibly a Cl effect on other metabolism. Photosynthesis and transpiration rates did not differ for cultivars.

34. Rehab, F.I., Wallace, A. and Khadr, A.H.: Growth and Mineral Composition of Cotton Grown in Solution Culture with Different Nitrogen Sources. Alex. J. Agric. Res. 27:173-176 (1979).

Cotton plants (*Gossypium* L. spp.) were grown in solution culture to further evaluate effects of nitrogen source on growth and mineral composition. Even with precautions taken to prevent drop of pH when NH_4^+ was the nitrogen source, plants with NH_4^+ did not grow quite as well as did plants with NO_3^- . Those with urea behaved like those with NH_4^+ and those with NH_4NO_3 were intermediate but some relation-

ships were not statistically significant. Plants supplied urea had slightly less N and those supplied with urea and NH_4NO_3 had less Ca in leaves than other plants.

35. Rehab, F.I., Wallace, A. and Romney, E.M.: Effect of Acidification of a Calcareous Soil on Yield and Mineral Composition of Three Cultivars of Cotton Grown in a Glasshouse. Alex. J. Agric. Res. 27:247-249 (1979).

Three cotton cultivars were grown for five weeks in calcareous Chino fine sandy loam soil variously amended with sulfur to result in various degrees of soil acidification. The objective was to determine effects on the micro-nutrient status of the cotton and if there were cultivar differences. Acidification to soil pH 5.5 improved vegetative yields significantly with two cultivars and also the third but not significantly. Acidification to soil pH 5.1 decreased vegetative yields for all three cultivars. The soil acidification probably overcome phosphorus deficiency. In addition to phosphorus, soil acidification increased leaf concentrations of potassium, manganese and silicon. It decreased leaf concentrations of Zn possibly the result of interactions with both phosphorus and manganese. Zinc deficiency was the probable cause of yield depression at pH 5.1.

36. Romney, E.M., Wallace, A. and Hunter, R.B.: Plant Response to Nitrogen Fertilization in the Northern Mohave Desert and Its Relationship to Water Manipulation. In Nitrogen in Desert Ecosystems, Hutchinson & Ross, Inc., Stroudsburg, PA, Chap. 16, pp. 232-243 (1978).

Water is generally considered to be the most limiting factor to primary productivity under desert conditions. If it is, then a logical conclusion is that additional water would increase productivity. This conclusion may not necessarily be correct if other limiting factors begin to operate immediately when more water is applied. Oxygen tension on roots is one possible example. Nitrogen is generally considered to be the next limiting factor after water, but many subtle effects of both nitrogen and water must be considered in the interaction of limiting factors in determining whether or not response to either will be obtained.

37. Strojan, C.L., Turner, F.B. and Castetter, R.: Litter Fall from Shrubs in the Northern Mojave Desert. Ecology, in press (1979).

(Ambrosia dumosa, Ephedra nevadensis, Krameria parvifolia, Larrea tridentata, Lycium andersonii and L. pallidum) in Rock Valley, Nevada. Collections were made between 1975 to 1977 and handsorted into leaves, stems, flowers and fruits. L. pallidum produced the most litter, with annual means ranging from 52 to 173 g/shrub⁻¹. Annual means per shrub for other species ranged from 39 to 89 g (L. andersonii), 27 to 77 g (L. tridentata), 20 to 29 g (E. nevadensis), 6 to 18 g (K. parvifolia)

and 3 to 21 g (*A. dumosa*). Litter fall was generally correlated with annual rainfall, which was low in 1975 (62 mm), high in 1976 (223 mm) and close to the long-term mean in 1977 (141 mm). Leaves were generally the largest litter category, followed by stems, fruits and flowers. Aboveground litter fall from the six species, which comprise about 82% of perennial plant biomass and about 81% of shrub cover in Rock Valley, was about 117 kg·ha⁻¹ in 1975 and 318 kg·ha⁻¹ in 1976. Total aboveground litter fall for Rock Valley (all perennial and annual plants) was estimated to be 194 kg·ha⁻¹ in 1975 and 530 kg·ha⁻¹ in 1976.

38. Turner, F.B. and Chew, R.M.: Secondary Production by Desert Animals. In Arid-Land Ecosystems, Goodall, D.W. and Perry, R.A., eds., Cambridge University Press, Vol. 2, in press (1979).

Production by desert animals was evaluated, with emphasis on vertebrates of southwestern U.S. Past work reviewed included studies of birds and mammals in Arizona and reptiles in southern Nevada. New estimates of productivity were derived for vertebrates in these areas, with particular attention to populations of pocket mice (*Perognathus formosus*) in southern Nevada. Simple models of production based on state variables of numbers or biomass were derived.

39. Turner, F.B., Edney, E.B. and Vollmer, A.T.: Ecological Effects of Precipitator Ash on Desert Plants and Animals. Annual Report to Southern California Edison, Research and Development Series, in press (1979).

A field experiment was established in Jackass Flats, Nevada to test possible effects of coal precipitator ash from the Mohave Generating Station on native vegetation. Related laboratory studies have examined effects of ash on growth and reproduction of tenebrionid beetles. Twenty-eight 15 x 15 m field plots were set out in seven blocks of four, with each block containing one untreated plot and three treated plots. Treatment levels were 10, 30 and 100 metric tons of ash per hectare. Six blocks were used in studies of four desert shrubs (creosotebush, bursage, desert tea and box thorn), and the other block was used for annual plants. No treatment-related effects were observed in the first growing season (1977), which was a poor one for growth of all desert plants. During the second season (1978) numbers of annual plants germinated were definitely reduced in plots exposed to 30 and 100 mt/ha of ash. The reduction was expressed both in terms of numbers of species and individuals recorded. Aggregate survival of germinated annuals was slightly improved in treated plots. Incidence of flowering and fruiting was not strongly affected among germinating annuals, but sizes of plants were sometimes increased in the most heavily treated plots, apparently owing to reduced competition at lower densities. Growth, phenology and reproduction by shrubs failed

to indicate clear-cut treatment effects. Among twelve growth variables analyzed (among four species) two indicated a significant treatment effect (changes in shoot length and new shoot growth per branch in bursage). Of ten reproductive variables analyzed, three showed treatment effects (numbers of flowers and fruits in creosotebush and inflorescences per branch in bursage). These effects showed no consistent pattern in terms of treatment levels. Phenology of shrubs was unaffected. Egg production by female beetles was unaffected by a diet amended with 5% ash, but was reduced by 10% and 25% ash diets. Body water content of adult females increased when beetles were fed ash-amended diets. When given unlimited water, beetles drank enough to maintain constant body weight, but those on a 25% ash diet drank about twice as much as controls. Ovaries of beetles fed 10 and 25% ash diets weighed less than half those of normal beetles, but testes were unaffected by treatments.

40. Turner, F.B., Medica, P.A. and Hill, H.O.: The Status of the Flat-tailed Horned Lizard (Phrynosoma mcallii) at Nine Sites in Imperial and Riverside Counties, California. Final 1978 Report to the Bureau of Land Management, 32 pp. (1978).

The status of Phrynosoma mcallii is under review by the Office of Endangered Species of the U.S. Fish and Wildlife Service. This species occurs in portions of Imperial County which are prospective lease areas for geothermal and/or oil and gas development. Nine areas in southeastern California were evaluated in 1978 in terms of soils, vegetation and the abundance of horned lizards. Soils in all areas were sandy and similar in texture and alkalinity. With one exception, plots supported typical mixtures of desert shrubs. Creosotebush and bursage had high importance values in all plots, and saltbush and mesquite were abundant in two or three plots. Numbers of perennial species ranged from two to eight, with diversities (H') as low as 0.25 and as high as 0.57. Aggregate perennial densities were high (>1000 plants/ha) in three plots, but generally low (<300/ha) in others. Aggregate cover ranged from <10% to 45%. Forty-four kinds of annual plants were identified, but only two were recorded in all plots. From 10 to 22 species of annuals were recorded in individual plots, and aggregate densities ranged from only 13/m² to over 1300/m². Diversities of annual plants were inversely correlated with densities. Ants made up >97% of all identified insects in lizard scats. Three species of harvester ants composed 75% of all ants in scats. Horned lizards were seen or captured in only four of the plots examined, and numbers observed per man-hour were generally low. The density of horned lizards was estimated to be around 6-8/ha in one plot in the Yuha Basin. Indexes of abundance of lizards were uncorrelated with at least 6 of 9 independent variables based on attributes of annual and perennial vegetation and numbers of nests of ants consumed by lizards. Horned lizard abundances were positively correlated with

aggregate densities of annuals and inversely correlated with annual diversity. Multiple regression analyses led to a three-term equation predicting an index of lizard abundance ($\bar{Y}$) from sampling data:

$$\bar{Y} = 35.6 - 132\Delta_1 + 130 \hat{H} + 0.9A$$

with Δ_1 the diversity of annuals, $\hat{H}$ the diversity of perennials, and A the number of active nests of harvester ants counted in ten 15 x 15 m quadrants. This equation accounted for 82% of observed variation in the dependent variable.

41. Turner, F.B., Strojan, C.L., Maza, B.G. and Heeb, M.M.: Trace Element Concentrations and Storages in Soils, Plants and Rodents in the Vicinity of the Mohave Generating Station in Southern Nevada. Final Report to the Environmental Protection Agency, EPA-1AG-D5-681-ACC, 59 pp. (1979).

Southern California Edison's 1580 Mw Mohave Generating Station went on line in 1970. Between 1975 and 1978 we made collections and chemical analyses of soils, plants and animals from near the Mohave station. Materials analyzed included surface soils (top 2 cm), annual plants; leaves, live and dead stems of shrubs; and various tissues of rodents. Measured concentrations of trace elements were used to estimate natural storages of these substances in various compartments of the desert environment surrounding the power plant.

Total concentrations (based on acid extractions) of 12 elements in surface soils ranged from 0.4-0.8 $\mu\text{g}\cdot\text{g}^{-1}$ (B, Cd) to around 200 $\mu\text{g}\cdot\text{g}^{-1}$ (Ba, Mn). Standing pools of elements in the upper cm of soil (the root milieu) ranged from 1.2 $\text{kg}\cdot\text{ha}^{-1}$ (B) to 669 $\text{kg}\cdot\text{ha}^{-1}$ (Mn). Standing pools of Co, Cr, Cu, Ni, Pb, S, Sr and Zn were on the order of 14-100 $\text{kg}\cdot\text{ha}^{-1}$.

Above-ground dry weight standing crops of shrubs (based on species composing ~80% of the communities) ranged from 1108 to 2526 $\text{kg}\cdot\text{ha}^{-1}$ at four sites near the Mohave station. Stem concentrations of B, Ba, Cu, Mn and Zn were around 10-50 $\mu\text{g}\cdot\text{g}^{-1}$; Mo and Pb concentrations were lower; Fe and Sr concentrations were usually in the range of 100-700 $\mu\text{g}\cdot\text{g}^{-1}$.

Estimated storages of Sr and Fe in plants were around 300-600 $\text{g}\cdot\text{ha}^{-1}$; of B, Ba, Cu, Mn and Zn about 15-60 $\text{g}\cdot\text{ha}^{-1}$; and of Mo and Pb <10 $\text{g}\cdot\text{ha}^{-1}$. Elemental storages (at four sites) could be well predicted by linear regression, using either shrub densities or biomass. Estimated storages of elements in annual plants (based on the 1976 flora) ranged from around 2 to 10% of storages in shrubs.

Estimated dry weight biomass of four species of rodents near the Mohave station ranged from 193 to 578 $\text{g}\cdot\text{ha}^{-1}$ between 1976 and 1978. Storages of B, Ba, Cu, Mo, Sr and Zn ranged from 0.2 to 37 $\text{mg}\cdot\text{ha}^{-1}$, with Zn the predominant element of those analyzed. Mean concentrations of fluoride

in rodent femurs ranged from around 350 to 500 $\mu\text{g}\cdot\text{g}^{-1}$ (of dry, defatted bone) at stations 2 to 20 km south of the Mohave station, considerably exceeding concentrations reported for uncontaminated environments in Montana (100-200 $\mu\text{g}\cdot\text{g}^{-1}$).

42. Wallace, A.: Excess Trace Metal Effects on Calcium Distribution in Plants. Commun. Soil Sci. Plant Anal. 10:473-479 (1979).

One of the most important roles of Ca in plants is that of protecting against toxicities of trace metals. Even though this is a function of Ca, at least some of the trace metals in excess do inhibit uptake and/or translocation of Ca. Manganese, when supplied at a very high level to bush beans (*Phaseolus vulgaris* L. cultivar Improved Tendergreen) in solution culture, decreased Ca concentration in leaves, stems and roots. The inhibition was pronounced for 10(E-3) and 10(E-2) M Mn. The decrease for the latter was 76% for leaves, 61% for stems, and 49% for roots. Molybdenum at 10(E-3) M decreased bush bean leaf, stem, and root concentrations of Ca by 38%, 24%, and 16%, respectively. Vanadate at 10(E-5) M decreased bush bean concentrations of Ca in leaves, stems, and roots by 37%, 50%, and 11%, respectively. Silver at 10(E-5) M decreased Ca in leaves by 67%. Cadmium at 10(E-4) M decreased leaf, stem, and root Ca by 76%, 28%, and 61%, respectively. Lithium at 50 ppm in soil decreased yields of bush beans by 75%, but had no effect on Ca in the shoots. In soil, 500 ppm Li decreased shoot yield of barley (*Hordeum vulgare* L. cultivar Atlas 57) by 66% and Ca concentration by 72%. Nickel (2 X 10(E-5) M) decreased Ca concentration in bush bean leaves by 45% at 10(E-4) M Ca, 42% at 10(E-3) M Ca, and 33% at 10(E-2) M Ca. In roots the reductions were 35%, 43%, and 41%, respectively. Decreased uptake of Ca caused by excess trace metals could increase their phytotoxicity.

43. Wallace, A. and Berry, W.L.: Accumulation of Trace Elements by a Population of Corn Plants During a Simultaneous Acute Exposure. In Plant Nutrition 1978. Proceedings of International Colloquium Plant Analysis and Fertilizer Problems, Ferguson, A.R., Bielecki, R.L. and Ferguson, I.B., eds., Auckland, New Zealand, D.S.I.R. Information Series No. 134, pp. 541-546 (1978).

Ninety corn seedlings from transplant were grown together in soil in a glasshouse with (in $\mu\text{g}/\text{g}$ soil) 133 Zn, 133 Cu, 67 Ni, 50 Co, 100 Cd and 13 Li all as sulfates blended with the soil. A set of 21 plants in a proportionate amount of soil was grown without added trace metals. Mean yield decrease for the treatment with added metals was 30%. Tissues of individual plants were analyzed for 25 mineral elements by arc emission spectrography. The degree and type of variability in elemental composition of tissue was determined for each element. Although individual ranges of 2- to 3-fold were found, the coefficient of variation was usually less than 20%. Correlation

matrix, cluster analysis, stepwise regression and frequency distribution analyses were performed to determine sources and types of variation.

44. Wallace, A. and El-Gazzar, A.M.: CaCO_3 as the Sole Source of Calcium in the Growth of Tomato Plants in Solution Culture. Alex. J. Agric. Res. 27:127-129 (1979).

Tomato plants (Lycopersicon esculentum L. cv. Tropic) grew satisfactorily in solution culture with an excess of CaCO_3 as the only source of Ca. Even though the pH of the nutrient solution was above 7, there was no Fe deficiency because sufficient Fe had been supplied as the chelate, FeEDDHA (ferric ethylenediamine di (o-hydroxyphenylacetic acid). No nutrient problems arose as result of the CaCO_3 .

45. Wallace, A., El-Gazzar, A. and Nassan, M.N.: Generalized Plant Nutritional Status of the Agricultural Lands of Egypt. Egypt J. Hort. 5:213-219 (1978).

More recycling of plant nutrients in Egypt than in the U.S.A. results in lower fertilizer requirements in Egypt. Limiting factors to agricultural productivity in Egypt by and large are not plant nutrients, but rather other aspects of management. Nitrogen is by far the most needed nutrient. At present the K status is in negative balance, but K-supplying powers of soils are probably such that very little K fertilization is needed at present. The P_2O_5 status is in balance and only crops responding to P need P fertilizers. Micronutrients, contrary to popular opinion, do not constitute major deficiency problems in Egypt. Boron can be excessive in some newly reclaimed land.

46. Wallace, A., El-Gazzar, A.M. and Khadr, A.H.: Ammonia vs. Nitrate in the Induction of Iron Deficiency and Growth of Bush Bean Plants. Alex. J. Agric. Res. 27:131-134 (1979).

We had previously reported that all NH_4^+ - N nutrient solutions were more conductive to the development of iron deficiency in plants than all NO_3^- - N plants. The purpose of this experiment was to further explore this relationship. An applied level of 0.02 N NH_4^+ in the presence of CaCO_3 as the sole source of Ca greatly restricted growth and caused leaf burn due to NH_4OH toxicity and had Ca deficient trifoliolate leaves without depressed Fe uptake. A level of 0.005 NH_4^+ with adequate Fe produced good plants free of Fe deficiency, but at a low Fe level this level of NH_4^+ resulted in Fe deficiency while a similar level of NO_3^- also at low Fe produced good plants free of Fe deficiency.

47. Wallace, A., El-Gazzar, A.M. and Patel, P.M.: Organic Acid Anions in Relationship to Cation and Nitrogen Nutrition in Tomato Plants. Alex. J. Agric. Res. 27:119-125 (1979).

Tomato plants (Lycopersion esculentem L. cv. Tropic) were grown in solution culture with different cation, nitrate and chloride treatments to result in different mineral anion and organic acid anion status. The amount of organic acid anions on the whole plant basis was more related to the total cation concentration of plants ($r = +0.912$) than to the total uptake of nitrogen which was supplied as all nitrate ($r = +0.778$). The ratio of total cations to organic acid anions was more constant than was the ratio of total N to organic anions. The respective ratios were $1.575 \pm 11.6\%$ C.V. (Coefficient of Variation) and $1.294 \pm 29.0\%$ C.V. The latter C.V. is $2\frac{1}{2}$ times the first.

48. Wallace, A., El-Sayed, G., El-Gazzar, A.M. and Hassan, M.N.: Leaf Analysis of Good, Intermediate and Stunted Sugar Cane in the Komombo Region of Egypt. Alex. J. Agric. Res. 27:161-167 (1979).

Samples (167) of sugar cane leaves (about 8 months old) (var. NCO-310) representing vigorous growth, intermediate growth and poor growth from nine different locations in the Komombo area of Egypt were assayed for 16 different mineral elements. Only sodium (salinity) excess was possibly related to the poor growth, indicating poor water management conditions. This conclusion is tentative only. Not all of the poor growth could be explained by poor water management or nutrition. There were no indications of micronutrient deficiencies or deficiencies of major elements. For several of the elements (boron, copper, zinc, magnesium and potassium), the coefficient of variation was much higher for the poor growth plants than for the healthy plants. This phenomenon may be important in interpretation of survey information for low and high yielding crops. There was indication that some mineral elements can be absorbed by leaves from dust.

49. Wallace, A. and Hassan, M.N.: Some Environmental Effects of the Aswan High Dam. Egypt J. Hort. 5:205-212 (1978).

Egypt had successfully irrigated lands for several millenia with water of very high quality. The Aswan High Dam began operation in 1968 and has provided much more water for agriculture, however, this can be a mixed blessing if management practices are not adjusted to account for the new contributions. Water management practices in Egypt, since the advent of the Aswan High Dam, have led to considerable waterlogging and salinization of soil. Excess use of water, even of high quality, without adequate drainage can produce poor results. New lands containing considerable salt have been reclaimed by pumping water to higher elevations and the effluent from these lands has increased the salt burden and water table of some adjoining lands to undesirable levels. Associated with the excess water use are secondary problems involving plant diseases and nematodes. The most important beneficial result to agriculture from the dam was capacity for more multiple cropping

(two or three crops) per year. Additional beneficial effects to agriculture of the dam are flood prevention as happened in 1975 and prevention of drought disasters such as those occurring in 1972-1973. Water and salt balances were calculated for the whole Nile River system in Egypt and indicate build up in the water table.

50. Wallace, A. and Mueller, R.T.: Complete Neutralization of a Portion of Calcareous Soil as a Means of Preventing Iron Chlorosis. Agron. J. 70:888-890 (1978).

Soybeans (Glycine max L. Merr., PI 54619-4-1) that are susceptible to Fe chlorosis, were grown in a glasshouse with calcareous (10% CaCO_3) Hacienda loam soil (fine-loamy, mixed, thermic aquic Natrargid) with a portion of the soil neutralized vs. equivalent mixing of sulfuric acid with all the soil. The objective was to determine if complete neutralization of only a small part of the mass of a calcareous soil could effectively prevent Fe chlorosis. Small acidified spots of soil, equivalent to as little as 0.4% of the CaCO_3 in the 1,000 g of the soil used in each pot, placed 3 cm deep under seedlings, was sufficient to prevent the Fe chlorosis. These glasshouse results suggest that comparable procedures be tried for field experimentation with row crops which are susceptible to Fe chlorosis.

51. Wallace, A., Mueller, R.T. and Alexander, G.V.: Influence of Phosphorus on Zinc, Iron, Manganese and Copper Uptake by Plants. Soil Science 126:336-341 (1978).

Five cultivars of soybeans (Glycine max L.) and a bush bean (Phaseolus vulgaris L. cv 'Improved Tendergreen') were grown in nutrient solutions with different P levels, solution pH, and, in the case of bush bean, at different Fe levels. The objective of the experiments was to obtain more definitive answers to problems of P-induced Zn and Fe deficiencies. Differential solution pH, obtained by adding solid phase CaCO_3 to the nutrient solution (about pH 7) vs. a regular solution (about pH 4-5), indicates that pH is very important in the effects obtained. At high pH, increasing solution P decreased the leaf, stem and root concentrations of Zn, Mn and Cu in soybeans. Iron was decreased in roots, but not in leaves and stems. In contrast, at low pH, increasing the P resulted in more Zn, Mn and Cu but less Fe in leaves, stems and roots. Results with bush beans were only slightly different from those with soybeans, and the Zn-P effects were modified slightly by Fe levels. High P decreased Fe transport to leaves in bush beans at low and high pH, but only at the high Fe level.

52. Wallace, A., Mueller, R.T. and Hartsock, T.: Effect of Irrigating Small Olive Trees Grown in a Glasshouse with Different Percentages of Seawater. Alex. J. Agric. Res. 27:221-224 (1979).

Small olive (*Olea wild*) trees (cuttings) were irrigated with different percentages of seawater to test physiological responses. The major objective was to determine if there were injurious effects in case such plants were irrigated with seawater in emergencies. After about 60 days adverse effects began to show on the plants irrigated with full seawater. This possibly was the result, at least in part, of build up of salt in the soil. At 169 days there were marked differences in growth, and in photosynthesis and transpiration rates for all seawater levels. The rates were decreased by all levels of seawater 169 days after start of treatment. Leaf Na levels of 0.38% and 0.85% CL may be excessive for these olives.

53. Wallace, A., Mueller, R.T., Wood, R.A. and Soufi, S.M.: Plant Uptake of Bicarbonate as Measured with the ^{11}C Isotope. Plant and Soil 51:431 (1979).

^{11}C which is cyclotron-produced by ^{14}N (p, α) ^{11}C (half-life 20.1 M) was used as a tracer of bicarbonate to determine its movements from a nutrient solution through roots to stems and leaves of bush bean plants (*Phaseolus vulgaris* L. var Improved Tendergreen). The short time involved and the high solution pH minimized the need for use of the Henderson Hasselbach equation for activity correction. Quantities of ^{11}C did move into roots, stems and leaves with a sharp decreasing gradient (root/stem = 14.5, stems/leaves = 11.7). More ^{11}C moved into plants with KHCO_3 than with NaHCO_3 . The $(\text{NH}_4)_2\text{SO}_4$ enhanced ^{11}C uptake and KNO_3 decreased it. This enhancement and competition indicated possibility of some uptake of HCO_3^- . In an experiment with *Galenia pubescens* (Eckl. and Zehl.) Druce, the ^{11}C was more readily moved to stems and leaves than in bush bean indicating substantial uptake of HCO_3^- .

54. Wallace, A., Patel, P.M., Berry, W.L. and Lunt, O.R.: Wastewater as a Hydroponic Growth Medium for Greenhouse Crop Culture. Alex. J. Agric. Res. 27:181-188 (1979).

Reclaimed water from a sewage plant at Calabasas, California was a satisfactory source of nutrients, except for iron, for growing crop plants in hydroponic culture under pilot plant commercial conditions. When solutions were renewed and adequate nutrients were present, commercial culture of a number of glasshouse crop plants could be grown without toxicity from salt or other materials. The crops were grown at energy savings compared with standard crop culture in that it was not necessary to use manufactured fertilizers. To avoid adding additional soluble nutrients to the sewage water, iron was supplied either as foliar spray or as insoluble iron oxide applied to plant roots before transplanting. The latter procedure was most satisfactory. Acidification of the water to pH 5 with sulfuric acid also overcame

the iron deficiency, but failed to make the plants grow because the sulfuric acid increased the availability of other trace metals to the point of excess. After the water had been used in the hydroponic tanks, much of the copper, zinc, manganese, iron, nickel, lead and some of the nitrogen, phosphorus and potassium had been stripped from the water.

55. Wallace, A., Procopiou, J., El-Gazzar, A.M. and Kinnear, J.: Variability in Mineral Composition of Orange Leaves of the Same Age and Collected from a Single Tree. Alex. J. Agric. Res. 27:55-62 (1979).

Variability was determined for composition of 17 different elements in 196 similar (same tree same age all from fruit bearing twigs) Valencia orange leaves. The range of concentration varied mostly around 4 but as many as 10 times. Some elements followed normal distribution and others did not. The natural coefficient of variation (C.V.) was usually between 10 and 20% but for some elements it was greater. The total C.V. was used to calculate the minimum sample size needed to assure a given accuracy in analysis. A cluster analysis was used to show how the various elements were related to each other. External contamination did not appear to be a major factor in the results.

56. Wallace, A., Romney, E.M. and Alexander, G.V.: Mineral Composition of *Cuscuta nevadensis* Johnston (Dodder) in Relationship to its Hosts. Plant and Soil 50:227-231 (1978).

The mineral composition of 16 samples of dodder (*Cuscuta nevadensis* Johnston) and leaves of eight species of its host plants collected from the northern Mojave Desert were examined to determine relationships between parasitism and transport of mineral elements from the host to the parasite. The K concentration of dodder was fairly constant for a wide range of host plants. It was sometimes less than and sometimes greater than that of the host. The concentrations of Ca, Mg, B, Mn, Mo and Sr in dodder were always much lower than those of leaves of host plants. Those of Fe, P and Al were sometimes higher. Sodium was generally excluded from dodder regardless of host concentration. Positive and significant correlation coefficients were obtained for concentration in dodder vs concentration in leaves of host plants for P, Na, Ca, Mg, Cu, Mn, Mo, Sr, Ba and Li. The coefficient of variation was less in the dodder than in leaves of the different host plants for 7 of 17 metals.

57. Wallace, A., Romney, E.M., El-Gazzar, A.M. and Khadr, A.H.: Leaf Absorption of Metals Deposited as Dust on Leaves. Alex. J. Agric. Res. 27:87-92 (1979).

Small trees were grown in pots under several environmental conditions (inside and outside of glasshouse and lathhouse) and leaves of constant age were assayed for metal absorption by emission spectrography after

three different preparation procedures. The experimental design was to determine if any elements deposited on leaves from the air became absorbed by the leaves. Iron, Al, Si, Ti and Cu were present on leaves from foliar contamination. Iron, Al, Si, Ti and possibly a slight amount of Cu appeared to be absorbed by leaves. Foliar contamination also may be a large source of Mn and Zn to tree leaves. Plants grown outside, but in shade, had a peculiar physiology. Bagging of leaves of field trees in clear plastic proved only that Fe and possibly Si were available to leaves from foliar contamination. Such bagging also caused peculiar physiology in leaves which obscured results.

58. Wallace, A., Romney, E.M. and Hunter, R.B.: Nitrogen Cycle in the Northern Mohave Desert: Implications and Predictions. In Nitrogen in Desert Ecosystems, Dowden, Hutchinson & Ross, Stroudsburg, PA, Chap. 14, pp. 207-218 (1978).

The nitrogen cycle in the northern Mohave Desert is characterized by a pool of nitrogen in the soil organic matter fraction from about 500 to 1,500 kg/ha, which is in equilibrium with mineral nitrogen fractions similar to those of other biomes and agricultural systems. The input of nitrogen and losses of nitrogen from the system are very small compared to the size of the soil organic nitrogen pool. Even so, the losses via runoff and leaching are sufficient to result in large accumulations of nitrate in the playas of closed basins common to the Mohave Desert. The amount of annual input is perhaps less than 1 kg/ha per year of newly fixed nitrogen and appears to be almost equally divided between that coming via nitrogenase systems and rainfall deposition. The mineralization process occurs at rates sufficiently high (before or near the time of critical phenological events) to create available nitrogen pools large enough to accommodate, without stress, a wide range of annual primary productivities resulting from differences in annual precipitation. If our conclusions about the relatively small annual inputs of newly fixed nitrogen are correct, then hundreds of years were necessary to obtain the pool sizes observed. We are unable to tell if they are at a steady state at the present time.

59. Wallace, A., Romney E.M., Kleinkopf, G.E. and Soufi, S.M.: Uptake of Mineral Forms of Nitrogen by Desert Plants. In Nitrogen in Desert Ecosystems, Dowden, Hutchinson & Ross, Stroudsburg, PA, Chap. 9, pp. 130-151 (1978).

Nitrogen uptake and assimilation by plants are key steps in nitrogen cycling in any ecosystem. Under desert conditions, information is lacking in most areas related to these problems. The forms and amounts of nitrogen which are available on a seasonal basis have not been satisfactorily documented. Nitrate concentrations are obviously low, but they are seasonally high enough to meet much, if not most, of the short-term plant need for nitrogen. Desert plants commonly respond

to addition of nitrogen fertilizer, especially when additional soil moisture is added. Mass flow of salts in water moved to the root could bring substantial quantities of nitrate to root surfaces even though the concentration in soils at any one time is low. Nitrogen recycling within the plant is a conservation measure which decreases need for new supplies of nitrogen from the external medium. The two processes just mentioned are most important in meeting the nitrogen needs of desert plants. The presence of nitrate in the leaves of some plant species implies that they absorb nitrate. Since nitrate reductase is an induced enzyme, its presence in field-grown plants also implies that nitrate is being utilized. There is more to be learned about the status and implication of nitrate reductase concentrations in desert plants. Ammonium and nitrate uptake have been studied for several species of desert plants under glasshouse conditions. The two forms of nitrogen can be taken up and assimilated with equal facility. In some cases, however, there seemed to be a lag in the rate of nitrate uptake since the ratio of nitrate: ammonium uptake increased with time. No critical studies have yet been made of the kinetics of nitrogen uptake by desert plants to indicate the degree of affinity which such plants might have for particular ionic forms of nitrogen. The ionic balance in some field-grown desert plants for which cation-anion values were estimated implies that nitrate is a major form of nitrogen taken up by desert plants. A steady state of nitrogen input and outgo in desert ecosystems may involve relatively small annual rates of each, with a sufficiently large pool of soil organic N which can buffer against high usage or high loss years.

60. Wallace, A., Romney, E.M. and Patel, P.M.: Role of Synthetic Chelating Agents in Trace Metal Uptake by Plants. In Environmental Chemistry and Cycling Processes, Proceedings of symposium at Augusta, GA, CONF-730429, TIC USOE, pp. 645-657 (1978).

Synthetic chelating agents have some agricultural uses for supplying deficient trace elements to plants. Agents that are used in varying degrees are not specific for the metals with which they are supplied and, therefore, tend to increase the transport of some unwanted metals into plants and, hence, into food chains. They can also promote leaching of trace metals from soil surfaces into lower soil horizons and to groundwaters. When synthetic chelates of iron, zinc or manganese are superimposed upon land areas that have already been contaminated with trace metals, the increased transport into plants is sometimes amplified by one or more magnitudes, depending on edaphic factors and the concentrations of metals. Soil pH is one of the most important factors determining uptake rates of trace metals in the presence of chelating agents. The greatest effect is usually obtained at the soil pH of maximum metal--chelate stability. Interactions do occur, and the maximum induced uptake is sometimes at low soil pH and sometimes

at high soil pH. The chelating agent most commonly associated with increased metal transport is diethylenetriaminepentaacetate (DTPA). Metals with known increased plant transport caused by chelating agents include Cd, Pb, Ni, Co, Cu, Zn, Cr, Fe and others. Chelating agents enhance the transport of at least some metals through plants. The effects are also pronounced with some radionuclides; most noteworthy is the transuranium element ^{241}Am . To a lesser extent the same effect is observed with $^{239-240}\text{Pu}$. Waste products from the nuclear fuel processing industry are often stored with chelating agents. Since potentially hazardous materials are often present, it is important to understand the relationships involved in the event that such materials should be accidentally dispersed into the environment.

61. Wallace, A., Romney, E.M. and Procopiou, J.: Effect of Different Rootstocks on the Nutrient Element Composition of the Scion Leaves in Citrus. Alex. J. Agric. Res. 27:63-66 (1979).

Fifty-four samples of mature leaves from bearing citrus trees grown in California on different rootstocks (10 on sweet orange, 14 on grapefruit, 7 on Cleopatra mandarin, 13 on rough lemon, 10 on sour orange) were assayed five times each with an emission spectrograph for P, K, Ca, Mg, Mn, Fe, Cu, Zn, B, Al, Si, Ni, Cr, Sr, Ba, Li and Na. Significant differences for rootstock were obtained for P, Ca, Mg, Mn, Cu, Zn, B, Al, Si, Sr and Li. Those on Cleopatra mandarin tended to be high in Mg, Mn, and Zn and low in Cu and P. Grapefruit was high in K and low in Mg.

62. Young, D.R., Moore, D.M., Alexander, G.V., Jan, T-K., McDermott-Ehrlich, D., Eganhouse, R.P. and Hershelman, P.: Trace Elements in Seafood Organisms Around Southern California Municipal Wastewater Outfalls. California State Water Resources Control Board Publication No. 60, 104 pp. (1978).

The purpose of this investigation was to determine the degree to which seafood organisms accumulate trace metals above natural levels in the vicinity of submarine municipal wastewater outfalls. Seventeen species of common California seafood organisms were selected for study. Where possible, tissues were separated into five classes (muscle, gonad, liver, kidney and skin) for trace element analysis. Two analytical techniques were utilized. Optical emission spectrometry was employed to simultaneously determine twenty six elements in all tissues. Where greater sensitivity was required atomic absorption spectrometry was applied on a single element basis.

No clear elevations above normal levels were found for any of the target metals in muscle of fishes collected near the wastewater outfalls. A number of the outfall invertebrates studied did contain distinct elevations of the various metals above control values. Most of the measurable contamination factors were less than 4; however, scallops and abalone collected around the Los Angeles County DWPCP outfall system contained up to 10 times control chromium levels in their muscle tissue.

DIVISION OF NUCLEAR MEDICINE

RESEARCH HIGHLIGHTS

The active research program in the Division of Nuclear Medicine during the reported year is reflected in the publication lists of 22 papers, 16 abstracts and 12 papers in press. The increasing excellence at both senior and junior investigator levels is indicated by the Georg von Hevesy award to the senior team of Gould, Schelbert, Phelps and Hoffman and by the Ralph Crump award to development engineer Ricci.

Among the enclosed abstracts, certain accomplishments are worthy of special attention. The pulmonary radioaerosol system has been simplified for more widespread use. The differential absorption of soluble radioaerosols has been characterized in normal subjects and those with systemic sclerosis affecting the lungs. The design and performance characteristics of positron tomographs have been characterized for the effect of object size, coincident detector spacing, slit shield geometry, accidental coincidence detection, sampling requirements and the effect of multiple gating. The effect of each of these must be known if quantitative imaging is to succeed in more complicated conditions. Emission computed tomography of the heart with nitrogen-13 ammonia during dipyridamole-induced coronary vasodilation was found capable of detecting mild coronary stenoses, giving promise for earlier diagnosis. ^{18}F labeled fluorodeoxyglucose was applied in the tomographic measurement of myocardial glucose metabolism. System requirements for quantification of local myocardial perfusion with radioactive ammonia were analyzed. The Sokoloff compartmental model for the measurement of cerebral metabolic rate for glucose was modified and validated to account for the dephosphorylation of FDG-6- PO_4 by glucose-6-phosphatase. The ^{18}F FDG and $^{13}\text{NH}_3$ tomographic methods were applied to patients with cerebral ischemia and otherwise undetectable zones of deactivated brain were found which correlated well with the patient's symptoms. The same scanning methods were applied to patients with partial epilepsy who were demonstrated to have hypometabolic cerebral zones in the absence of seizures and hypermetabolic zones in the presence of seizures. The conditions under which radioammonia serves as a good blood flow tracer in the brain were better defined.

These accomplishments account for the growing role of this Division as a premier center for investigation of local organ metabolism and circulation by means of quantitative reconstruction tomography.

ABSTRACTS

1. Bruce, D., Obrist, W., Zimmerman, R., Bilaniuk, C., Dolinkas, C., Kuhl, D. and Schut, L.: The Pathophysiology of Acute Severe Brain Swelling Following Pediatric Head Trauma. In Cerebral Blood Flow and Metabolism, Gotoh, F., Nagai, H. and Tazaki, Y. eds., Acta Neurol. Scan. Suppl. 72, 60, Munksgaard, Copenhagen, pp. 372-373 (1979).

Acute severe brain swelling, sometimes referred to as "malignant brain edema," has been described following head trauma. This pattern is most frequently described in children and it is interesting to note that the commonest autopsy finding in children dying from head trauma is of a severely swollen brain with minimal or no evidence of underlying primary brain injury. In the process of studying 85 children with prolonged unconsciousness following head trauma, we have identified changes in blood flow and brain density which give us an insight into the pathophysiology of "malignant brain edema."

Thirty six of 85 severely head-injured children (Glasgow Coma Score of 8 or less) aged 2 months to 17 years were defined as having a CT pattern of diffuse cerebral swelling. This pattern was defined as an initial CT scan which demonstrated marked narrowing or obliteration of the lateral and third ventricles, the perimesencephalic and quadrigeminal plate cisterns and a general loss of subarachnoid space and a follow-up scan 1-3 weeks later which demonstrated an increase in size of the ventricular and subarachnoid spaces back to normal. A number of patients, not included in the 36 reported here, have had small changes in ventricular size but this has not been felt to have been adequate to include them definitively as diffuse brain swelling.

The clinical history and examination of these children clearly divided them into 2 groups. In group 1, 16 children had an initial episode of unconsciousness lasting for greater than 10 minutes followed by some degree of recovery. From 30 minutes to 12 hours later there was a sudden decrease in level of consciousness associated with sweating, pallor, intermittent and frequently alternating pupillary dilatation, bradycardia, systemic hypertension and sometimes intermittent decerebration. At least 1 episode of apnea occurred in 25% of these patients. In group 2, 20 children were deeply unconscious from the time of injury and exhibited either flaccidity or bilateral decerebration. None of these 20 patients had a lucid period and this group appeared to have suffered a much greater degree of primary brain injury.

Using the Mark I EMI Scanner, white matter frontal lobe densities were compared on the initial and follow-up scans in 12 patients with comparable artifact-free scans. 150-300 pixels were average. Control data was obtained by utilizing frontal lobe density in the hemispheres of 6 normal children aged 5 to 16 years. The density on the initial scan was increased above normal and a decrease to the normal range on follow-up scans. This was statistically significant at the $p < .01$ level.

One child was studied with a regional cerebral blood volume measurement which showed an increase in blood volume acutely which decreased during recovery. Although the blood volumes are clearly very restricted, it was felt that the increase in brain density was indeed compatible with an increase in cerebral blood volume and incompatible with an increase in cerebral water content and that acute edema was not the cause of the diffuse brain swelling seen on CT scan.

In an effort to further delineate the pathophysiology, CBF was measured using the I.V. Xenon 133 method with external counting with the 16-probe detector system. The CBF was measured in 6 adolescent patients, aged 14 to 20 years with CT pattern of diffuse swelling and in 8 similarly neurologically injured patients aged 17 to 20 years whose CT scan did not demonstrate diffuse swelling. The CBF was increased above normal in those patients with diffuse swelling and decreased below normal, 25-30%, in those patients without diffuse swelling. The CMRO₂'s were the same in both groups of patients. Thus, this pattern of diffuse swelling is also associated with an increase in CBF as well as with an increase in brain density.

Group 1 patients were intubated and moderately hyperventilated. The ICP rarely rose and these patients made an excellent recovery within 2-7 days. Group 2 patients had initially low ICP but 15 of the 20 developed an ICP of greater than 20 Torr from 24-72 hours post injury. This elevated ICP was difficult to control despite hyperventilation, steroids, moderate dehydration and barbiturates in coma doses were required in 12 of these 15 patients. In only 1 case was the ICP uncontrollable by such therapy and that patient died an intracranial death. This patient, however, had no perfusion pressure at the time the bolt was inserted and it is hardly surprising that therapy was ineffectual. The difference in ICP correlates well with the difference in early clinical course and in late clinical course. All the Group 2 patients took many weeks to recover completely and 90% of this group were transferred to rehabilitation centers prior to being discharged home.

The follow-up data in Group 1 patients show there were no deaths, only 1 patient had residual focal injury and 90% of those of school age were in the correct grade. In Group 2, there was a 10% mortality, 10% were severely incapacitated and 35% had focal neurological deficits. Of those of school age, only 75% were in their correct grade; or 25% were in special schools for the handicapped. Follow-up CT scans confirmed the clinical impression in that Group 1 patients showed essentially normal CT scans without any evidence of atrophy. In Group 2 patients, 65% showed evidence of extracerebral collections of CSF over the frontal lobes within 1 week to 10 days post injury, 70% showed evidence of progressive ventricular and sulcal enlargement consistent with cerebral atrophy and 50% of these showed return of the ventricular size to normal after 1 year. Autopsy examination on the 2 patients who died revealed evidence of diffuse impact injury within the white matter of the brain and of the corpus callosum.

The pattern of diffuse brain swelling, which we believe is the neuro-radiological correlate of "malignant brain edema," is associated with vasodilatation and cerebral hyperaemia. This event can occur with minimal primary impact brain injury in which case supportive respiratory therapy is all that is required to insure excellent recovery, or it can occur in association with severe multifocal primary impact injury to the brain. The clinical history and examination readily differentiate between the 2 groups of patients. Group 2 patients are likely to develop a delayed increase in ICP because of the delayed development of slowly progressive multifocal cerebral edema associated with a multifocal brain injury and the underlying hyperaemia. While further regional cerebral blood volume studies are required to prove that the cerebral blood volume is indeed elevated as well as the blood flow we believe at this point that acute brain swelling in children following head injury is produced by acute cerebral vasodilatation and cerebral hyperaemia.

2. Bruce, D.A., Raphael, R.C., Goldberg, A.S., Zimmerman, R.A., Bilaniuk, L.T., Schut, L. and Kuhl, D.E.: The Pathophysiology, Treatment and Outcome Following Severe Head Injury in Children. Child's Brain 5:174-191 (1979).

The pathophysiology and outcome following severe head injury in 85 children are presented. The commonest initial CT diagnosis was of acute brain swelling. This swelling was associated with an increased white matter density on the CT scan which decreased to normal concomitant with recovery and increased ventricular size. CBF measurements of 6 of these patients revealed an increased blood flow despite a decreased CMRO₂ and clinical coma. This CT pattern of diffuse swelling is believed to be due to acute cerebrovascular congestion and hyperemia and not to edema. Because of this, all children were treated with endotracheal intubation and controlled hyperventilation as part of the initial management. Mass lesions were uncommon, 20%. ICP was monitored in 40 children. The ICP rose above 20 Torr despite therapy in 80% of children with decerebrate or flaccid coma and in only 20% of children with spontaneous motor function. The ICP was at its highest between the second and fifth day. Aggressive therapy to control the ICP, with barbiturates if necessary, was successful in 80% of the patients. The overall results were useful recovery in 87.5% of the children, 3.5% were left vegetative or severely disabled and 9% died.

3. Cohen, M.B., Spolter, L., Chang, C.C., Cook, J.S. and MacDonald, N.S.: Enzymatic Synthesis of C-11 Pyruvic Acid and C-11 L-Lactic Acid. Int. J. Applied Radiation and Isotopes, in press (1979).

Lactic acid is readily utilized by the myocardium. An enzymatic synthesis for C-11 lactic acid was therefore devised and is performed

in two steps: 1) production of C-11 pyruvate from C-11 CO₂ and acetyl CoA in the presence of an enzyme extracted from *Clostridium acidurici*, 2) conversion of C-11 pyruvate to lactic acid by lactic dehydrogenase. Alternatively, pyruvate may be transaminated to C-11 L-alanine by glutamic-pyruvic transaminase.

The incubation mixture contained the following substances in a total volume of 2 ml: C-11 carbon dioxide, 30-40 mCi; ferredoxin, 2×10^{-6} mmole; ferredoxin reductase, 0.1 unit; NADPH, 8×10^{-2} mmole; acetyl CoA, 2×10^{-2} mmole; acetyl phosphate, 2.9×10^{-2} mmole; phosphotransacetylase, 25 units; cysteine, 5×10^{-3} mmole; potassium phosphate buffer, 17.6×10^{-2} mmole; NADH, 1.24×10^{-3} mmole; lactate dehydrogenase, 50 units; pyruvate-ferredoxin oxidoreductase, approx. 1 mg. After anaerobic incubation at 37°C for 10 minutes, the sample was passed through an AG 50W x 8 resin column which had been equilibrated with 0.1N sodium acetate buffer, pH 2.3. The effluent was then passed through an AG 1 x 8 resin column which had been equilibrated with HCL at pH 3 and then washed with double distilled water. A yield of about 3-5% (corrected for decay) was obtained in 20 minutes. The identity of the C-11 lactate was established by paper chromatography and by its behavior in various chromatographic columns, where it acted like standard lactic acid.

Tissue distribution studies in rabbits have demonstrated a 7:1 myocardium to lung ratio for C-11 lactic acid, which is suitable for quantitative tomographic imaging.

4. Gould, L., Schelbert, H.R., Phelps, M.E. and Hoffman, E.J.: Non-Invasive Assessment of Coronary Stenosis with Myocardial Perfusion Imaging During Pharmacologic Coronary Vasodilatation. V. Detection of 47% Diameter Coronary Stenosis with Intravenous Nitrogen-13 Ammonia and Emission-Computed Tomography in Intact Dogs. Am. J. Cardiol. 43:200-208 (1979).

To determine the minimal coronary lesions detectable with perfusion imaging, 16 stenoses of 43 to 66 percent diameter narrowing were applied to the left circumflex coronary artery of three chronically instrumented intact dogs. Orthogonal diastolic coronary arteriograms, obtained on cut film by triggering X-ray exposures from the electrocardiogram while injecting contrast medium through a chronically implanted coronary arterial catheter, were analyzed quantitatively by computer. Fifteen millicuries of nitrogen-13 ammonia was injected intravenously during resting conditions, and emission-computed tomography was performed without electrocardiographic gating. One hour later, after residual nitrogen-13 ammonia had decayed, 15 mg of intravenous dipyridamole was given followed by a second dose of intravenous nitrogen-13 ammonia and repeat performance of emission-computed tomography. The cross-sectional tomographs of the heart were of high quality and revealed in the images obtained with

dipyridamole definite perfusion defects with coronary stenoses of 47 percent or greater diameter narrowing. Stenoses of 45 percent diameter narrowing or less did not produce perfusion defects. Quantitative perfusion abnormalities approximated the quantitative severity of stenoses. It is concluded that noninvasive myocardial emission-computed tomography with nitrogen-13 ammonia during dipyridamole-induced coronary vasodilatation detects mild coronary stenoses for purposes of potential medical intervention.

5. Greenberg, J.H., Alavi, A., Reivich, M., Kuhl, D. and Uzzell, B.: Local Cerebral Blood Volume Response to Carbon Dioxide in Man. Circ. Res. 43:324-331 (1978).

We used an emission tomographic brain scanner to investigate the relationship between local cerebral blood volume (LCBV) and arterial blood carbon dioxide tension (PaCO_2) in normal awake man. Measurements were made separately in three dimensions in various regions of grey and white matter, and the resting LCBV as well as the difference in sensitivity among these regions were compared. Over the range of PaCO_2 studied (20-42 torr), the response of both the grey matter and the white matter to carbon dioxide was linear. The LCBV sensitivity of the grey matter to changes in PaCO_2 was 0.053 ml/100 g per torr PaCO_2 and in the white matter this sensitivity was 0.46 ml/100 g per torr PaCO_2 . These sensitivities were found not to be significantly different, yielding a slope of 0.049 ml/100 g per torr PaCO_2 for the LCBV- PaCO_2 curve for the entire brain. This is in excellent agreement with the other data for the whole brain. The resting cerebral blood volume of the grey matter at a PaCO_2 of 34.4 torr, which was the average resting arterial carbon dioxide tension of the subjects, was 5.0 ml/100 g and was significantly higher than for white matter, which was 3.6 ml/100 g. At the local level, the cerebral blood volume of the frontal cortex is significantly less than that of the thalamus, whereas the frontoparietal cortex in the region of the sylvian fissure has a local cerebral blood volume significantly greater than that of the thalamus.

6. Greenberg, J., Alavi, A., Reivich, M., Kuhl, D. and Uzzell, B.: Local Cerebral Blood Volume Response to Carbon Dioxide in Man. J. Comput. Assist. Tomogr. 2:660, abstract (1978).

The Mark IV tomographic brain scanner has been used to measure the local cerebral blood volume (LCBV) response to alterations in arterial blood carbon dioxide tension (PaCO_2) in a series of normal young male volunteers. This emission scanner is capable of measuring brain tissue activity in a 1.8 x 1.8 x 1.7 cm tissue volume. By labeling a sample of a subject's red blood cells (RBC) with $^{99\text{m}}\text{Tc}$, local cerebral blood volume can be calculated for this tissue region. After the subject was positioned in the scanner, he was given 20 mCi $^{99\text{m}}\text{Tc}$

labeled RBC intravenously. Brain scans were obtained with the subject breathing room air, a 3% CO₂ mixture, a 5% mixture and with the subject voluntarily hyperventilating to an end-tidal CO₂ concentration of 3.0%. The subject was allowed to equilibrate at each CO₂ level for at least 10 min prior to the scan. During each tomographic brain scan, arterial blood samples were withdrawn from a brachial arterial catheter for analysis of PaCO₂, PaO₂ and pH as well as measurements of blood 99mTc activity.

Cerebral blood volume was examined in three gray matter areas (thalamus, frontal cortex and insular cortex in the region of the sylvian fissure) and in three white matter areas (frontal white, internal capsule and occipital white). In all areas, inhalation of carbon dioxide caused an increase and hyperventilation caused a decrease in LCBV. For the purpose of some of the data analysis, the gray matter structures were averaged together and taken to be representative of the cerebral gray matter, and the white matter structures were averaged and taken as representative of cerebral white matter. Over the range of PaCO₂ studied (20 to 42 torr), the responses of both gray and white matter to carbon dioxide were linear. The individual LCBV response to CO₂ of all the subjects are shown in Fig. 1. The gray matter LCBV sensitivity to changes in PaCO₂ (0.053 ml/100 g/torr PaCO₂) was not statistically different from the sensitivity of the white matter (0.046 ml/100 g/torr PaCO₂) yielding a whole brain LCBV sensitivity to carbon dioxide of 0.049 ml/100 g/torr PaCO₂. This is in excellent agreement with the data in the literature. The resting cerebral blood volume of the gray matter at a PaCO₂ of 34.4 torr (8.0 ml/100g), however, was significantly higher than for white matter (3.6 ml/100 g).

The reproducibility of the technique was assayed by examining the two initial sequential section scans obtained on each subject at the beginning of the study. The coefficient of variation of LCBV in this test-retest situation was 4.3% for gray and 3.0% for white matter. If we correct the second scan to the PaCO₂ of the first scan, the coefficient of variation becomes 3.4% and 2.9% for the gray and white matter, respectively.

When the LCBV response to carbon dioxide of the individual gray matter areas were examined, it was found that there were no significant differences in sensitivity to arterial carbon dioxide alterations. The resting cerebral blood volumes of the three areas, however, were significantly different. The cerebral blood volume of the frontal cortex (3.93 ml/100 g) was significantly less than that of the thalamus (5.00 ml/100 g), while the insular cortex had a blood volume (5.86 ml/100 g) significantly higher than the thalamus. There were neither significant differences in sensitivity to carbon dioxide, nor in resting LCBV for the three white matter areas examined in this study.

7. Hoffman, E.J., Huang, S.C. and Phelps, M.E.: Quantitation in Positron Emission Computed Tomography: 1. Effect of Object Size. J. Compt. Tomogr. 3:299-308 (1979).

The effect of object size on the capability of positron emission computed tomography to measure isotope concentrations in a cross section was studied. The relationship between the apparent isotope concentration in an image and the true concentration was measured as a function of object size for three instrument resolutions and four convolution filters. The relationship between image size and object size was also measured under the same conditions. Depression of apparent isotope concentration in an image for objects equal in size to the instrument resolution (FWHM) was significant (50% for a cylinder and 25% for a bar). For objects larger than 1.0 FWHM, accurate object sizes can be estimated from the images. Thus, reasonably accurate and practical schemes of compensation for object size effects can be implemented for objects larger than 1.0 FWHM. Accuracy in quantitating isotope concentrations in smaller objects is seriously compromised by the loss of sensitivity to the object size and the large correction factors required to compensate for instrument response. The results of the measurements were found to be in good agreement with theoretical predictions for ideal systems of comparable resolution.

8. Hoffman, E.J. and Phelps, M.E.: Emission Computed Tomography with Positrons. Med. Instr. 13:147-151 (1979).

Conventional nuclear imaging techniques utilizing lead collimation rely on radioactive tracers with little role in human physiology. The principles of imaging based on coincidence detection of the annihilation radiation produced in positron decay indicate that this mode of detection is uniquely suited for use in emission computed tomography. The only gamma-ray-emitting isotopes of carbon, nitrogen and oxygen are positron emitters, which yield energies too high for conventional imaging techniques. Thus development of positron emitters in nuclear medicine imaging would make possible the use of a new class of physiologically active, positron-emitting radiopharmaceuticals. The application of these principles is described in the use of a physiologically active compound labeled with a positron emitter and positron-emission computed tomography to measure the local cerebral metabolic rate in humans.

9. Hoffman, E.J., Phelps, M.E., Huang, S.C. and Kuhl, D.E.: Effect of Accidental Coincidence in Positron Emission Computed Tomography. J. Nuc. Med. 20:634-635, abstract (1979).

Errors caused by detection of accidental coincidence (ACs) and techniques for removing these events from data were investigated in terms of their effect on quantitation in Positron Emission Computed Tomography (PCT).

Removal of ACs is accomplished by simultaneous measurement of total coincidence events and ACs followed by an on line subtraction of the ACs from the total coincidences. Sequential phantom studies with short-lived positron emitters, which were performed with increasing scan times to compensate for isotope decay, gave images of constant true coincidence counts and variable AC fractions (0-50%). Images of pure ACs were obtained with phantoms containing TC-99m.

Errors in measured isotope concentrations in images were linearly related to AC fractions and are a function of size and shape of cross section and isotope distribution. For a 20 cm diameter uniform distribution of activity, a 50% (25%) AC rate contributed 46% (23%) of counts at center of cylinder, giving overestimates of 85% (33%) for concentration of positron emitter. Images of pure ACs show count distributions varying 2 to 1 from center to edge of field of view with a definite geometric pattern of 10-20% oscillations superimposed. This pattern, due to differences in true and accidental detection efficiencies, is removed by the on line AC subtraction technique.

ACs were found to create significant and correlated errors in PCT, indicating a need for accurate correction techniques which take into account the nature of this source of error.

10. Hoffman, E.J., Phelps, M.E., Ricci, A.R., Huang, S.C. and Kuhl, D.E.: Optimization of System Design Parameters for Emission Computed Tomography. IEEE Nucl. Sci., in press (1979).

Two design parameters (coincident detector spacing and slit shield geometry) are singled out for investigation as to their influence on two of the more intractable problems in PCT design (spatial uniformity and scatter coincidence rejection). The effect of spatial non-uniformity on the extraction of quantitative information from images is shown. The magnitude and spatial distribution of scatter coincidences and the influence of slit shield design and detector spacing on scatter coincidences is shown. A new multiplane geometry is suggested which allows the high precision of a single plane PCT system and high efficiency of a multiplane PCT system to be combined in one system.

11. Hoffman, E.J., Phelps, M.E., Wisenberg, G., Schelbert, H.R. and Kuhl, D.E.: ECG Gating in Positron Emission Computed Tomography. J. Comput. Tomogr., in press (1979)

ECG synchronized multiple gated data acquisition was employed with positron emission computed tomography (PCT) to obtain images of myocardial blood pool and myocardium. The feasibility and requirements of multiple gated data acquisition in PCT were investigated for $^{13}\text{NH}_3$, $(^{18}\text{F})\text{-2-D-deoxyglucose}$ and $(^{11}\text{C})\text{-carboxyhemoglobin}$. Examples are shown in which image detail is enhanced and image interpretation

is facilitated when ECG gating is employed in the data collection. Analysis of count rate data from a series of volunteers indicates that multiple statistically adequate images can be obtained under a multiple gated data collection format without increase in administered dose.

12. Huang, S.C., Hoffman, E.J., Phelps, M.E. and Kuhl, D.E.: Sampling Requirements of Emission Computed Tomographic (ECT) Scanners. J. Nuc. Med. 20:609, abstract (1979).

Sampling distance is an important consideration in ECT scanner design. Insufficient sampling can create aliasing artifacts on images. By computer simulation of equally spaced parallel lines, reconstruction of various frequency components in images can be examined separately. Various line spacing ($\Delta L=1.0$ to 1.6 cm), FWHM's ($W=0.4$ to 1.2 cm), and sampling distances ($\Delta T=0.3$ to 1.0 cm) have been used in simulations to study the inter-relationships that would give reconstructions free of aliasing artifacts. Point sources have also been simulated to examine aliasing effects on isolated point sources. Line spread functions have been assumed to have a Gaussian shape and standard filtered backprojection with ramp filter functions have been used for image reconstruction.

It was found that, for $\Delta T > \Delta L/2$, parallel lines are not reconstructed correctly. Some parallel lines are seen on images, but line locations are incorrect and total number of lines seen is smaller than true number. For $W/3 < \Delta T < \Delta L/2$, total number of lines is correct, but line spacing and line widths are not uniform on image. Only for $\Delta T < W/3$ can lines be reconstructed uniformly and consistently. Contrast of reconstructed lines decreases as W increases. For $W > 0.92\Delta L$, reconstructed contrast is smaller than 5% of original. For point sources, insufficient sampling is reflected in variability of reconstructed activity depending on location. For $\Delta T > 2W/3$ variability is larger than 10% of correct value. It is concluded from this study that 1) FWHM should be smaller than 0.92 times desirable image resolution to obtain reasonable recovery and sampling distance should be smaller than 1/3 of FWHM to prevent aliasing and 2) equally spaced line patterns could be used as a sensitive and convenient phantom for checking sampling adequacy of ECT scanners.

13. Huang, S.C., Schelbert, H.R., Phelps, M.E., Hoffman, E.J., Selin, C.J. and Kuhl, D.E.: Single Pass Extraction of N-13 Ammonia by Myocardium and Its Relationship to Myocardial Blood Flow. J. Nuc. Med. 20:648, abstract (1979).

Myocardial single pass extraction fraction (E) and its relationship to myocardial perfusion (F) was determined in 5 open chest dogs. Flow probes were placed around the left circumflex coronary artery (CIRC) and calibrated using intra-atrial injections of radioactive micro-

spheres ($8m$) and the arterial reference sampling technique. Studies were performed at control flows and during CIRC hyperemia induced by intracoronary papaverine (1mg). For each study a bolus of N-13 ammonia was injected into the CIRC and myocardial activity monitored continuously by an external detector. Immediately after injection, the time activity curve reached a maximum, followed by a fast and a slow clearance component. E was determined by the fraction of the slow component to the peak of the curve. Two to five measurements at different CIRC flows were performed in each dog resulting in a total of 23 studies. E was found to decrease as flow increases, similar to that observed by us previously using the *in vitro* counting technique. At F equal to 100, 200 and 300 ml/min/100gm, E is 0.82, 0.65 and 0.57, respectively. The relationship between E and F can be represented by $E = 1 - 0.635 \exp(-121/F)$ with an average standard deviation of 0.059. This relationship does not match exactly that of CRONE'S extraction model in which $\ln(1-E)$ is inversely proportional to F. The discrepancy can be interpreted as either 1) that the permeability surface area product (PS) is $0.455F + 121$ ml/min/100 gm, a linear function of flow, or 2) that there are two distinct extraction mechanisms in myocardium, one with $PS = 121$ ml/min/100 gm and the other with $PS \gg 300$ ml/min/100 gm.

14. Ido, T., Wan, C.N., Casella, V., Fowler, J.S., Wolf, A.P., Reivich, M. and Kuhl, D.E.: Labeled 2-Deoxy-D-Glucose Analogs. 18-F-Labeled 2-Deoxy-2-Fluoro-D-Glucose. J. Labelled Compounds and Radiopharmaceuticals 14:175-183 (1978).

A convenient method for the synthesis of ^{18}F -2-deoxy-2-fluoro-D-glucose and ^{18}F -2-deoxy-2-fluoro-D-mannose by the direct fluorination of 3,4,6-tri-O-acetyl-D-glucal with ^{18}F -F₂ is described. ^{14}C -2-deoxy-2-fluoro-D-glucose has been synthesized from ^{14}C -3,4,6-tri-O-acetyl D-glucal (from D-[^{14}C (U)]-glucose) by fluorination with F₂ (Method 1) and CF₃OF (Method 2). These labeled analogs of 2-deoxy-D-glucose were required for the study of local cerebral glucose metabolism.

15. Jengo, J.A., Mena, I., MacDonald, N. and Criley, J.M.: Evaluation of Left Ventricular Function (Ejection Fraction and Segmental Wall Motion) By Single Pass Radioisotope Angiography. Int. J. Nuc. Med. and Biol. 6:35-44 (1979).

Ejection fraction is a sensitive indicator of left ventricular function but can only be determined accurately by contrast ventriculography or, more recently, gated cardiac blood pool scans. However, even ejection fraction may not faithfully reflect changes in ventricular function during on-going ischemia.

Therefore, it is necessary to measure segmental wall motion in addition to ejection fraction and the hemodynamic parameters of left ventricular function.

Using cardiac catheterization techniques and bolus injections of Technetium-99m, it was shown that single pass radioisotope angiography is easily performed, rapid (requiring only 30 sec of data acquisition), does not alter left ventricular function and can be performed in any projection. If a radioisotope with a short biological half-life is used (for example 99m-technetium-DTPA) studies can be repeated after 2-3 hr. If a Krypton-81m generator is available, studies can be repeated at 2 minute intervals because of the 13 second physical half-life.

This technique correlates well with contrast angiographic determinations of ejection fraction and segmental wall motion and allows for serial determinations of left ventricular function, and therefore is especially applicable to evaluating critically ill patients and can be incorporated into the management of these patients in an intensive care unit setting.

16. Kuhl, D.E., Engel, J., Jr., Phelps, M.E. and Kowell, A.P.: Epileptic Patterns of Local Cerebral Metabolism and Perfusion in Man: Investigation by Emission Computed Tomography of ^{18}F -Fluorodeoxyglucose and ^{13}N -Ammonia. Annals of Neurol. 4:167, abstract (1978).

Eight patients with partial epilepsy underwent continuous electroencephalographic monitoring during emission computed tomography, from which brain radioactivity was reconstructed in cross-sectional pictures. ^{18}F -tagged fluorodeoxyglucose (^{18}FDG) and ^{13}N -labeled ammonia ($^{13}\text{NH}_3$) were used as indicators of local changes in cerebral glucose utilization and relative perfusion, respectively. We have already established that in normal subjects, the relative cerebral distributions of ^{18}FDG and $^{13}\text{NH}_3$ are matched in anatomical structures and are predictable.

Interictal scans done on 2 patients who had bifrontally synchronous spike activity on EEG were normal. In contrast, 4 of the 5 patients with predominantly unilateral temporal spike activity had ipsilateral scan abnormalities consisting of 20 to 50% depression in cortical ^{18}FDG accompanied by a lesser depression in $^{13}\text{NH}_3$. Ictal scans done on 2 patients showed increased nuclide concentration localized to cortical sites of unilateral focal electrical activity. In 1 patient the increased focal concentration was ^{18}FDG , 107%; $^{13}\text{NH}_3$, 37%. In the other patient, separate studies during two different ictal episodes gave increased focal concentrations: first study-- ^{18}FDG , 117%; $^{13}\text{NH}_3$, 52%; second study-- ^{18}FDG , 51%; $^{13}\text{NH}_3$, 36%. In this patient, an interictal scan showed no focus of increased nuclide concentration but instead a 25% depression of ^{18}FDG in the ipsilateral cortex accompanied by a normal $^{13}\text{NH}_3$ distribution. These studies indicate the potential of emission computed tomography for defining local cerebral physiology in partial epilepsy.

17. Kuhl, D.E., Engel, J., Phelps, M.E. and Selin, C.: Patterns of Local Cerebral Metabolism and Perfusion in Partial Epilepsy by Emission Computed Tomography of ^{18}F -Fluoro-Deoxyglucose and ^{13}N -Ammonia. In Cerebral Blood Flow and Metabolism, Gotoh, F., Nagai, H and Tazaki, Y. eds., Acta Neurologica Scandinavica 60:538-539 (1979).

Ten patients with partial epilepsy underwent ECAT positron tomography during continuous surface or depth EEG monitoring. ^{18}F -fluorodeoxyglucose (^{18}FDG) and ^{13}N -ammonia were given intravenously as indicators of cerebral glucose utilization (LCMR_{glc}) and relative perfusion, respectively.

We found that the interictal ^{18}FDG scan patterns clearly show localized regions of decreased (20%-50%) LCMR_{glc} which correlate anatomically with interictal spike foci (6 of 7 patients). These zones were not detectable by x-ray CT. The localized metabolic depressions probably represent regions of permanently damaged brain rather than transiently suppressed function since, in 4 patients, focal metabolic depressions were unchanged in interictal scans repeated on different days. The interictal ^{18}FDG scans were not sensitive to changes in interictal focal spike activity. There were no differences between interictal scans made during period of high and periods of low focal spike activity in paired studies of 3 patients. In all of three mentally retarded patients with diffuse or multifocal EEG abnormalities, the interictal ^{18}FDG scans demonstrated only globally decreased LCMR_{glc} . On the other hand, the ictal ^{18}FDG scan patterns clearly showed foci of increased (82%-130%) LCMR_{glc} which correlated temporally and anatomically with ictal EEG spike foci (3 studies in 2 patients). In both patients, the hypermetabolic ictal focus coincided anatomically with the zone of interictal hypometabolism.

$^{13}\text{NH}_3$ distributions paralleled ^{18}FDG increases and decreases in abnormal zones, but $^{13}\text{NH}_3$ differences were of lesser magnitude. Measurements of compression ischemia and penicillin-induced epileptic foci in dog brains showed $^{13}\text{NH}_3$ underestimated increases and decreases in local blood flow determined by the microsphere method. When this relationship was applied as a correction to the patient's $^{13}\text{NH}_3$ scan data, alterations in perfusion and glucose utilization were usually matched in abnormal zones, both in the interictal and ictal states.

18. Kuhl, D.E., Phelps, M.E., Engel, J., Hoffman, E.J., Robinson, G.D., Jr., MacDonald, N.S., Kowell, A.P. and Winter, J.: Relationship of Local Cerebral Glucose Utilization and Relative Perfusion in Stroke and Epilepsy: Determination by Emission Computed Tomography of Fluorine-18 Fluorodeoxyglucose and Nitrogen-13 Ammonia. J. of Comp. Asst. Tomogr., abstract (1978).

By means of emission computed tomography (ECT), we used ^{18}F -fluoro-deoxyglucose (FDG) and ^{13}N -ammonia as indicators of abnormalities in

local cerebral glucose utilization and relative perfusion, respectively. The ECAT positron tomograph was used to scan 10 normal subjects used as controls, 10 patients with acute and chronic cerebral ischemia from stroke, and 8 patients with partial epilepsy.

In the 10 control subjects, where local perfusion normally is regulated by and matched to local metabolic activity, we found local distributions of ^{18}F -FDG and ^{13}N -ammonia matched in all structures, i.e., frontal, temporal, parietal and occipital gray matter, visual cortex, basal ganglia and white matter.

In the 10 stroke patients, those with acute arterial occlusions had focal inhomogeneities and mismatches of the two indicators, which reflected noncoupling of the usual perfusion-metabolism relationship. In regions of complete ischemia, both glucose utilization and perfusion were markedly depressed. Focal reactive zones of increased or "luxury" perfusion had normal, increased, or decreased glucose utilization. The peripheral zones of some early infarcts showed increased glucose utilization, probably due to enhanced anaerobic glycolysis in hypoxic but still perfused border zone. Few of these relationships could have been inferred in these patients from results of X-ray CT alone. In one patient with a small internal capsule hemorrhage, X-ray CT was the only abnormal study, but in several other patients, X-ray CT was normal, while ECT showed definite metabolic defects that matched clinical dysfunction.

The 8 patients with partial epilepsy underwent continuous electroencephalographic monitoring before, during and after ECT. Interictal scans were normal on two patients with bifrontally synchronous spike activity on EEG. In contrast, four of the five patients with predominantly unilateral temporal spike activity had ipsilateral scan abnormalities consisting of 20 to 50% depression in cortical ^{18}F -FDG accompanied by lesser depression in ^{13}N -ammonia.

Ictal scans on two patients showed increased nuclide concentration localized to cortical sites of unilateral focal electrical activity. In one patient, the increased focal concentration was: ^{18}F -FDG, 107%; ^{13}N -ammonia, 37%. In the other patient, separate studies during two different ictal episodes gave increased focal concentrations as: (1) ^{18}F -FDG, 117%, ^{13}N -ammonia, 52%; (2) ^{18}F -FDG, 51%, ^{13}N -ammonia, 36%. In this patient, an interictal scan showed no focus of increased nuclide concentration, but instead a 25% ^{18}F -FDG depression in the ipsilateral cortex accompanied by a normal ^{13}N -ammonia distribution.

These studies indicate the significant potential of ECT for defining local cerebral physiology, not only in normal man under laboratory conditions but also in patients with a wide variety of cerebral disorders, including stroke and partial epilepsy.

19. Makler, P.T., Jr., Gutowicz, M.F. and Kuhl, D.E.: Methotrexate-Induced Ventriculitis: Appearance on Routine Radionuclide Scan and Emission Computed Tomography. Clin. Nucl. Med. 3:22-23 (1978).

A 9-year-old boy with acute lymphocytic leukemia underwent intrathecal methotrexate (MTX) treatment over a period of one year because of CNS symptoms. After a sudden rapid deterioration, radionuclide imaging demonstrated marked ventricular wall concentration, presumed related to MTX toxicity. After cessation of MTX treatment, the patient improved, and subsequent radionuclide images reverted to normal appearance.

Visualization of the ventricles on a brain scan can be due to transport of ^{99m}Tc -pertechnetate by the choroid plexus (if no potassium perchlorate was administered or if the patient has a choroid plexus papilloma or to increased vascular permeability in the ventricular walls. The reported causes of increased vascular permeability in the ventricular walls are infection (bacterial or tuberculosis) or damage due to either anoxia, hyperthermia, or chemical irritation. Visualization of the ventricles on brain scan due to irritation from intrathecal administration of methotrexate has previously been described by Conway. We present here what we believe is the first published report of static emission images and emission computed tomograms in ventriculitis.

20. Phelps, M.E., Hoffman, E.J., Huang, S.C. and Kuhl, D.E.: Design and Performance Characteristics of the ECAT Positron Tomograph. J. Comput. Assist. Tomogr. 2:648, abstract (1978).

The ECAT (Ortec, Inc., Oak Ridge, Tennessee) is a positron imaging system capable of providing quantitative, high contrast, high resolution whole body images in both two-dimensional (2-D) and tomographic formats. The flexibility in its various image mode options makes it useful for a wide variety of imaging problems.

21. Phelps, M.E., Hoffman, E.J., Huang, S.C. and Kuhl, D.E.: Design Considerations in Positron Computed Tomography (PCT). IEEE Nucl. Sci. NS-26:2746-2751 (1979).

PCT system design is complex and involves optimization and tradeoffs in numerous design parameters. A design approach or system evaluation in terms of FWHM resolution and gross efficiency is insufficient and misleading. There are many sources of noise in PCT other than statistical which must be minimized. When they become competitive with statistical noise, then further increases in efficiency will not produce significant improvements in performance and image signal/noise. At this time, circumferential systems are more optimal than planar arrays for PCT. The advantages and disadvantages of the hexagon and circle need to be analytically determined in more detail.

22. Phelps, M.E., Hoffman, E.J., Huang, S.C., Schelbert, H.R. and Kuhl, D.E.: Emission Computed Tomography: A New Technique for the Quantitative Physiologic Study of Brain and Heart In Vivo. Annals of Biomedical Engineering, in press (1979).

Emission computed tomography (ECT) has a number of unique capabilities because of its capability to quantitatively measure physiologic processes as compared to the morphological or anatomical capabilities in TCT or ultrasound. This can be clearly appreciated from the fact that ECT can be combined with labeled body substrates and physiologic models to provide analytical measurements of physiologic variables such as metabolism, flow, membrane transport, etc. This is achieved through the capability of ECT to analytically measure tissue activity concentrations *in vivo*. In this way ECT can be used in the *in vivo* setting in analogy to the *in vitro* experimental techniques of quantitative autoradiography and tissue counting techniques which have been employed in a laboratory setting to study basic physiologic and patho-physiologic processes. This total capability has been referred to as physiologic tomography (PT).

PT requires labeled compounds which trace physiologic processes in a known manner, and physiologic models which are appropriately formulated and validated to derive physiologic variables from ECT data. In order to effectively achieve this goal, PT requires an imaging system that is capable of performing truly quantitative or analytical measurements of tissue concentrations and a system that has been well characterized in terms of resolution, sensitivity and signal to noise ratios in the image.

23. Phelps, M.E., Hoffman, E.J., Selin, C., Huang, S.C., Robinson, G., MacDonald, N.S., Schelbert, H. and Kuhl, D.E.: Investigation of 18-F-2-Deoxyglucose for the Measure of Myocardial Glucose Metabolism. J. Nuc. Med. 19:1311-1319 (1978).

F-18 labeled 2-deoxyglucose (FDG) was studied as a glucose analog for the measure of myocardial glucose metabolism. Myocardial uptake and retention, blood clearance, species dependence (dog, monkey, man), and effect of diet on uptake were investigated. Normal myocardial uptake of FDG was 3-4% of injected dose in dog and monkey, and 1-4% in man, compared with brain uptakes of 1.5-3% in dog, 5-6% in monkey, and 4-8% in man. The myocardial metabolic rate (MR) for glucose in the non-fasting (glycolytic) state was 2.8 times that in the fasting (ketogenic) state. Human subjects showed higher myocardial uptake after a normal meal than after meal containing mostly free fatty acids (FFA). Blood clearance was rapid with initial clearance $t_{1/8}$ of 0.2-0.3 min, followed by a $t_{1/8}$ of 8.4 ± 1.2 min in dog and 11.6 ± 1.1 min in man. A small third component had half-times of 59 ± 10 min and 88 ± 4 min in dog and man, respectively. With the ECAT positron tomograph, high image-contrast ratios were found between

heart and blood (dog 3.5/1, man 14/1), heart and lung (dog 9/1, man 20/1), and heart and liver (dog 15/1, man 10/1). FDG was found to be taken up rapidly by the myocardium without any significant tissue clearance over a 4-hr period. FDG exhibits excellent imaging properties. Average counting rates of 12K, 20K and 40K c/min-mCi injected are obtained in human subjects with high, medium and low resolutions of the ECAT tomograph. Determination of glucose and FFA MR *in vivo* with ECT provides a method for investigation and assessment of changing aerobic and anaerobic metabolic rates in ischemic heart disease in man.

24. Phelps, M.E., Huang, S.C., Hoffman, E.J., Selin, C.E. and Kuhl, D.E.: Tomographic Measurement of Cerebral Blood Volume with C-11 Labeled Carboxyhemoglobin. J. Nuc. Med. 20:328-334 (1979).

Red blood cells, tagged with C-11 by administration of ^{11}CO gas, have been used to portray the distribution of blood in the brain. To date, however, the accuracy of this approach has not been validated. We have performed *in vitro* measurements of regional cerebral blood volume (CBV) with red blood cells labeled with C-11 and Cr-51 in four dogs and two rhesus monkeys. These studies yielded a ratio of $\text{CBV}_{\text{C-11}}$ to $\text{CBV}_{\text{Cr-51}}$ of 1.02 ± 0.03 (s.d.) from 92 samples. A least-squares fit to these data showed $\text{CBV}_{\text{C-11}} = 1.01 \text{ CBV}_{\text{Cr-51}} + 0.037$; $P < 0.001$. The ratio of CBV in gray matter to that in white matter was 2.8 ± 0.4 ($n = 12$) and 3.1 ± 0.6 ($n = 8$). *In vivo* studies with emission computed tomography (ECT) and ^{11}CO -RBC gave coefficients of variation of $\pm 2.8\%$ and $\pm 4.8\%$ for cross-sectional CBV and regional ($\sim 4 \text{ cm}^2$) CBV over an 80 min period. The average human CBV was found to be 4.2 ± 0.4 cc blood per 100 g tissue. Clear tomographic delineation of the distribution of CBV in human subjects is achieved with ECT, which provides a "live" measurement of this parameter of cerebral hemodynamics. These data demonstrate that ^{11}CO administered by single-breath inhalation is a reliable and accurate blood tracer for measurement of CBV with ECT.

25. Phelps, M.E., Huang, S.C., Hoffman, E.J., Kuhl, D.E.: Tomographic Measure of Local Cerebral Metabolic Rate for Glucose (LCMRGlc) in Man with 2(F-18)Fluoro-Deoxyglucose (FDG): Validation of Method. In Cerebral Blood Flow and Metabolism, Gotoh, F., Nagai, H. and Tazaki, Y. eds., pp. 200-201, Acta Neurologica Scandinavica 60 (1979).

FDG has been used with emission computed tomography (ECT) by Reivich et al., Kuhl et al., and Phelps et al. to measure LCMRGlc. However, no one has reported rate constants and lumped constants (LC) for FDG in any animal and deoxyglucose (DG) values only exist for rat and monkey (Sokoloff et al., Kennedy et al.). The rate of dephosphorylation of FDG-6-PO₄ has not been measured and if significant, to incorporate it into a compartmental model. Precision of ECT measure of LCMRGlc with FDG has also not been determined.

We used the ECAT tomograph to measure the capillary transport (k_1^* , k_2^*), phosphorylation (k_3^*) and dephosphorylation (k_4^*) rate constants for various gray and white matter structures and have estimated LC in 15 subjects. Although small, k_4^* (0.0073 and 0.0050 min^{-1} in gray and white matter) is significant. We have derived an extension of the model of Sokoloff et al. which accounts for dephosphorylation. Compared to DC in rat, our values of k_1^* and k_2^* are about 1/2, whereas k_3^* and LC are similar. Compartmental concentration of FDG and FDG-6- PO_4 show that cerebral FDG-6- PO_4 increases for about 100 min, plateaus and then slowly decreases ($t_{1/2} = 9 \text{ hr}$). Precursor pool turnover rates, distribution volumes and red blood cell/plasma ratios were determined. Precision of LCMRGlc for 2 cm^2 regions is $\pm 5.5\%$ from repeated studies over 5 hours in 12 subjects. Normal values for gray and white matter structures range from 5.5 to 10.1 and 2.1 to 4.5 $\text{mg}/\text{min}/100 \text{ gms}$. Arterial blood sampling is replaced by sampling venous blood from hand heated to 45°C (produces arterial-venous shunt). Error analysis is applied to determine model sensitivity to errors in k^* 's and for optimization of measurements. Model, k^* 's and LC are incorporated in ECAT so that LCMRGlc can be extracted from images with region of interest (ROI) capability. As ROI is used to survey image, LCMRGlc, size and std. dev. in region are displayed in real time. System is set up so that studies are routinely carried out by technicians.

Images show clear delineation of cerebral structures (left and right caudate and thalamus, internal capsule, etc.) for measure of CMRGlc. This study illustrates the technique of physiologic tomography.

26. Phelps, M.E., Huang, S.C., Hoffman, E.J., Selin, C.E. and Kuhl, D.E.: Tomographic Measurement of Regional Cerebral Glucose Metabolic Rate in Man with (^{18}F) Fluorodeoxyglucose: Validation of Method. Ann. Neurol., in press (1979).

Tracer techniques and models of in vitro quantitative autoradiography and tissue counting for the measure of regional metabolic rates (rMR) are combined with emission computed tomography (ECT). This approach, Physiologic Tomography (PT), provides atraumatic and analytical measurements of rMR. PT is exemplified with the regional measurement of the cerebral metabolic rate for glucose (CMRGlu) in man with (^{18}F)-2-deoxy-2-fluoro-D-glucose (FDG) and positron ECT. A three compartmental model has been derived as an extension of the model developed by Sokoloff and coworkers. Our model incorporates a k_4^* mediated hydrolysis of FDG-6- PO_4 and reverse transport (k_2^*) back to blood. Although small, k_4^* is found to be significant. The ECAT positron tomograph was used to measure the rate constants (k_1^* , k_4^*), lumped constant (LC), stability and reproducibility of model in man. Since these parameters have not been measured for FDG in any species, comparisons are made to values for DG in rat and monkey. Compartmental concentrations of FDG and FDG-6- PO_4 were determined and show that cerebral FDG-6- PO_4 steadily accumulates for about 100 mins, plateaus and then slowly decreases due

to hydrolysis. Cerebral blood FDG concentration was determined to be a minor contribution to tissue activity after about 10 min. Precursor pool turnover rates, distribution volumes and red blood cell-plasma concentration ratios are also determined. Regional CMRGlucose measurements are reproducible to $\pm 5.5\%$ over 5 hours. Animal and human studies show arterial blood sampling can be replaced with venous blood without loss in accuracy. PT allows the in vivo study of regional biochemistry and physiology in normal and pathophysiologic states in man with a unique and fundamental capability. This study exemplifies the use of ECT to not only apply but to also investigate and validate a PT approach. PT can potentially allow characterization and detection of cerebral disease at early stages where treatment and reversibility have a better perspective.

27. Phelps, M.E., Huang, S.C., Hoffman, E.J., Selin, C.S., Sideris, K. and Kuhl, D.E.: Validation of the Noninvasive Tomographic Measure of Regional Cerebral Glucose Metabolism in Man with ^{18}F -2-Fluoro-2-Deoxyglucose. J. Comput. Assist. Tomogr. 2:656-657, abstract (1978).

The compartmental model for the autoradiographic measure of cerebral metabolic rate for glucose (CMRGlucose) developed by Sokoloff and co-workers for deoxyglucose (DG) has been modified and validation studies carried out in man with ^{18}F -2-fluoro-2-deoxyglucose (FDG). The modification of the Sokoloff et al. model consisted of the rigorous derivation of the model to account for the dephosphorylation of DG-6- PO_4 by glucose-6-phosphatase.

28. Phelps, M.E., Huang, S.C., Kuhl, D.E., Selin, C. and Hoffman, E.J.: Can N-13 Ammonia Be Used As A Cerebral Blood Flow Tracer? J. Nuc. Med. 20:611, abstract (1979).

N-13 ammonia was originally proposed by Hunter-Monohan and Harper et al for imaging heart, brain and liver. Phelps et al proposed that uptake in brain and heart was proportional to capillary perfusion via a unidirectional Renkin-Crone Model with metabolic trapping. Studies in brain by Phelps et al and Schelbert et al in heart provided support to this concept. Since $^{13}\text{NH}_3$ is not a flow limited tracer in brain and heart, response of $^{13}\text{NH}_3$ uptake will be nonlinear with flow and dependent on capillary permeability-surface area product (PS) and rate of metabolic trapping and release.

Relationship between $^{13}\text{NH}_3$ uptake in brain was studied in 16 dogs. Cerebral blood flow (CBF) variations were produced by i) embolization of left hemisphere/elevated PaCO_2 and ii) local compression in left hemisphere/elevated PaCO_2 and iii) local penicillin induced seizure with a wide CBF range (0 to 250 cc/min/100 gms). $^{13}\text{NH}_3$ was injected I.V. and CBF measured with μ spheres. Relative local tissue, $^{13}\text{NH}_3$ and ammonia flow index (i.e. using μ sphere model) had a near linear response from 0 to 80 cc/min/100 gms, but above 80 response became progressively nonlinear. Response was very similar for animal models

i, ii and iii, and for different cerebral structures, except grey matter was more responsive. Rankin-Crone Model, although crude, provides a basis for interpretation of data.

$^{13}\text{NH}_3$ is a good flow tracer in heart due to its high PS product. Lower PS of brain makes it a good flow tracer at medium to low flow but not very high flow. $^{13}\text{NH}_3$ appears to be a good flow tracer for cerebral ischemia.

29. Phelps, M.E., Huang, S.C., Schelbert, H.S., Hoffman, E.J. and Kuhl, D.E.: Physiologic Tomography Measure of Cerebral and Myocardial Metabolic Rate for Glucose (MRGlc): Models and Measurement Optimization, J. Nuc. Med. 20:605-606 (1979).

Pharmacokinetic and physiologic studies require compartmental tracer kinetic models as a framework for developing evaluation and application of physiologically active labeled compounds. These models provide i) description of process, ii) method for evaluating physiologic integrity of compound and iii) operational eqs. for calculation of rate constants (k 's), metabolism, binding affinity, etc.

We derived a 3 compartment model for FDG in brain and heart as an extension of Sokoloff's model. K 's of model are measured for brain in man and heart in dogs. Measured range of k 's are used to determine error limits in measure of MRGlc with average k 's and to optimize study protocols. Initially after injection, model is sensitive to errors in k 's and dependent on blood flow (BF). After 40 min, near steady state conditions are reached, sensitivity to exact k 's and BF are reduced. Precision of repeated tomographic MRGlc studies in 13 subjects (brain) and 6 dogs (heart) is $\pm 5\%$. Dog studies were performed to determine BF sensitivity of model. Papaverine, in left circumflex artery (LCX) was used to produce high BF (450cc/min/100gm) and normal MRGlc. MRGlc with FDG was normal and equaled LAD region. A 15 min occlusion and release of LCX produced hyperemia BF of 500cc/min/100gms and blockage of glucose metabolism (tissue acidosis). FDG MRGlc in LCX was 10% of LAD region even though BF was 6 times higher. Thus model reflects metabolism and not BF. Emission tomography (ECT) provides in vivo measurements not previously possible. Combining labeled physiologic compds that behave in predictable manner with physiologic models allow ECT to be developed.

30. Phelps, M.E., Schelbert, H.R., Hoffman, E.J., Huang, S.C. and Kuhl, D.E.: Physiologic Tomography of Myocardial Glucose Metabolism, Perfusion and Blood Pools with Multiple Gated Acquisition. Clin. Card., in press (1979).

Positron computed tomography (PCT) provides an analytical, non-invasive method for measuring local tissue concentrations of administered labeled compounds in man. This capability when combined with labeled substrates or substrate analogs that behave in a known or predictable manner and

physiologic tracer models forms the basis of physiologic tomography (PT). PT can provide the cardiological sciences with a unique method for investigating the local biochemical and functional changes that occur in human myocardial disease.

This paper illustrates the principles of PT by examples of a PCT system, a compartmental tracer kinetic model for the measurement of the myocardial metabolic rate for glucose (MMRGlc) with a glucose analog (F-18) fluorodeoxyglucose (FDG), measurements of the precision of the local MMRGlc measurements, a tracer model for the measurement of myocardial blood flow with (N-13) ammonia, gated blood pool imaging and gated myocardial studies for wall thickening.

Numerous university, commercial and governmental programs are actively contributing to the development of this technique and to determination both its unique capabilities, limitations and technical requirements to make it a practical investigative tool.

31. Reivich, M., Kuhl, D.E., Wolf, A., Greenberg, J., Phelps, M.E., Ido, T., Casella, V., Fowler, J., Hoffman, E., Alavi, A. and Sokoloff, L.: The [^{18}F] Fluorodeoxyglucose Method for the Measurement of Local Cerebral Glucose Utilization in Man. Circ. Res. 44:127-137 (1979).

A method has been developed to measure local glucose consumption in the various structures of the brain in man with three-dimensional resolution. [^{18}F]-2-deoxy-2-fluoro-D-glucose is used as a tracer for the exchange of glucose between plasma and brain and its phosphorylation by hexokinase in the tissue. A mathematical model and derived operational equation are used which enable local cerebral glucose consumption to be calculated in terms of the following measurable variables. An intravenous bolus of [^{18}F]-2-deoxy-2-fluoro-D-glucose is given and the arterial specific activity monitored for a predetermined period of from 30 minutes to 120 minutes. Starting at 30 minutes, the activity in a series of sections through the brain is determined with three-dimensional resolution by an emission tomographic scanner. The method was used to measure local cerebral glucose consumption in two normal volunteers. The values in gray matter structures range from 5.79 mg/100 g per minute in the cerebellar cortex to 10.27 in the visual cortex, whereas, in white matter structures, the values range from 3.64 mg/100 g per minute in the corpus callosum to 4.22 in the occipital lobe. Average values for gray matter, white matter, and whole brain metabolic rates, calculated as a weighted average based on the approximate volume of each structure, are 8.05, 3.80, and 5.90 mg/100 g per minute, respectively. The value of 5.9 mg/100 g per minute compares favorably with values previously reported.

32. Ritchie, J.L., Zaret, B.L., Strauss, H.W., Pitt, B., Berman, D.S., Schelbert, H.R., Ashburn, W.L., Berger, H.J. and Hamilton, G.W.: Myocardial Imaging with Thallium-201: A Multicenter Study in Patients with Angina Pectoris or Acute Myocardial Infarction. Am. J. Cardiol. 42:345-350 (1978).

A multicenter study of rest and exercise thallium-201 myocardial imaging in 190 patients from five centers was performed. Exercise images were obtained after graded treadmill or bicycle stress with use of five different gamma camera models and were interpreted by the originating investigator without knowledge of other clinical data. Of 42 patients with less than 50 percent coronary stenosis, 4 (10 percent) had a resting image defect, 1 (2 percent) a new exercise defect and 5 (12 percent) either a resting or an exercise image defect, or both. Of 148 patients with coronary stenosis of 50 percent or greater, 64 (45 percent) had an image defect in the study at rest, 90 (61 percent) had new or increased defects after exercise, and 115 (78 percent) had resting or exercise defects, or both. New exercise image defects were more common than exercise S-T depression (90 of 148 [61 percent] versus 62 of 148 [42 percent]; $P < 0.01$). In a second group of 111 patients with acute myocardial infarction studied at three centers, 90 patients (81 percent) had image defects compared with 71 (64 percent) who had new electrocardiographic Q waves ($P < 0.01$). Smaller infarctions, as assessed with serum enzyme values, and diaphragmatic infarctions were less commonly detected than larger or anterior infarctions. These findings suggest that myocardial imaging complements the electrocardiographic identification of acute myocardial infarction or exercise-induced myocardial ischemia.

33. Robinson, G.D., Jr.: Cyclotron Related Radiopharmaceutical Development Program at UCLA. Progress in Nuclear Medicine 4:80-92 (1978).

The UCLA program for developing radiopharmaceuticals incorporating cyclotron-produced radionuclides has recently emphasized ^{18}F , ^{123}I and ^{62}Cu . Simple aliphatic fluorocarboxylate derivatives are labeled with ^{18}F by interhalogen replacement with ^{18}F -fluoride adsorbed on anion exchange resins. ^{18}F -2-fluorocethanol shows promise as an agent for direct imaging of regional cerebral perfusion. Reaction of ^{18}F -labeled HF and BF_3 with ethylene oxide are being pursued as alternative pathways to ^{18}F -2-fluoroethanol. A reliable, high-yield method for production of ^{123}I -iodide using the $^{124}\text{Te}(p,2n)^{123}\text{I}$ reaction has been developed. ^{123}I -16-iodo-9-hexadecenoic acid has been prepared and is being used in clinical studies as an agent for myocardial perfusion imaging. ^{123}I -o-iodohippurate has been synthesized in quantitative radiochemical yields and is being evaluated as a substitute for ^{131}I -o-iodo-hippurate in human renal studies. A simple $^{62}\text{Zn}/^{62}\text{Cu}$ generator system for production of 9.8-min ^{62}Cu has been developed and a series of radiopharmaceutical kits for rapid preparation of ^{62}Cu -labeled radiodiagnostic agents has been devised.

34. Robinson, G.D., Jr. and Lee, A.W.: Reinvestigation of the Preparation of ^{131}I -4-iodoantipyrine from ^{131}I -Iodide. Int. J. of Applied Radiation and Isotopes 30:365-367 (1979).

Radioiodine labeled 4-iodoantipyrine (4-IAP) is rapidly formed from radioiodide and nonradioactive 4-IAP or 4-bromoantipyrine (4-BrAP) at 100°C in acidic aqueous solution. Quantitative conversion to labeled 4-IAP is observed between pH 2 and 6 when 4-IAP is the nonradioactive starting material. This is in contrast to previous reports which found rapid incorporation only under limited conditions. When 4-BrAP is used, maximum yields of 80% are found between pH 1.5 and 2.5. Mechanistic implications of these differences are not clear. Labeled 4-IAP ($\geq 98\%$ radiochemically pure) is separated from radioiodide by TLC or anion-exchange chromatography.

35. Robinson, G.D., Jr., Lee, A.W. and Zielinski, F.W.: The Zinc-62/Copper-62 Generator: A Convenient Source of Copper-62 for Radiopharmaceuticals. Int. J. Appl. Radiat. Isotopes, in press (1979).

^{62}Cu is a short-lived (9.8 min) positron emitter which results from the decay of ^{62}Zn (9.2 hour). ^{62}Zn is easily produced in good yield (2.3 mCi/ μA hour) by bombardment of a 0.4-mm thick target of natural copper with 22 MeV protons. A simple separation of zinc and copper as chloride complexes using anion exchange chromatography is described.

The performance of a $^{62}\text{Zn}/^{62}\text{Cu}$ generator system based upon a similar anion exchange separation is evaluated. Using a 0.7-cm I.D. x 8.0-cm high column of "Dowex 1-X10" resin of 200 to 400 mesh, eluted with 0.1 N HCl containing 100 mg/ml NaCl and 1 μg /ml CuCl_2 , over 85% of the available ^{62}Cu is recovered in a 3.5 ml volume. The ^{62}Zn level is less than 0.001% at the time of elution. A variety of potentially useful radiopharmaceuticals using this generator system have been developed and are being evaluated in clinical trials.

36. Schelbert, H.R. and Phelps, M.E.: Physiologic Tomography: A New Means for the Non-invasive Measurement of Myocardial Metabolism, Blood Flow and Function. European J. A. M., in press (1979).

This article provides a short description of positron emission computed axial tomography and currently available positron emitting radiopharmaceuticals as they pertain to the evaluation of cardiac perfusion, metabolism and mechanical function. The advantages of this new technique over conventional two-dimensional gamma camera imaging are emphasized, the importance of physiologic models for quantification of myocardial metabolism stressed and the future potential of physiologic tomography for an improved understanding of cardiac physiology, more accurate characterization of cardiac pathology and the possibility for earlier detection of cardiac disease perhaps at a preclinical stage indicated.

37. Schelbert, H.R., Phelps, M.E., Hoffman, E.J., Huang, S.C., Selin, C. E. and Kuhl, D.E.: Regional Myocardial Perfusion Assessed by N-13 Labeled Ammonia and Positron Emission Computerized Axial Tomography. Am. J. Cardiol. 43:208-218 (1979).

The usefulness of N-13 ammonia as an indicator of regional myocardial perfusion suitable for positron emission tomography has been suggested. However, the relation between myocardial blood flow and uptake of N-13 ammonia has not been examined quantitatively. To quantitate the relation of myocardial N-13 ammonia tissue concentration to myocardial blood flow and examine its suitability for positron emission tomographic imaging, 12 open chest dogs were studied. In eight of the dogs, 25 imaging procedures with N-13 ammonia and positron emission tomography were performed; in the remaining four dogs the relation between flow and myocardial N-13 ammonia concentration was assessed with in vitro techniques. Positron emission tomography provided high quality cross-sectional images of the distribution of N-13 ammonia in left ventricular myocardium. No significant redistribution of N-13 ammonia in the myocardium occurred with time. Alterations in regional myocardial blood flow resulted in changes in the regional distribution of N-13 ammonia that were visible in the cross-sectional images. Myocardial N-13 ammonia concentrations measured with positron emission tomography were closely related to myocardial blood flow, although in a nonlinear fashion.

The nonlinear relation determined with positron emission tomography was identical to that observed with in vitro techniques. The nonlinearity of this relation of flow to N-13 ammonia concentration was probably due to the inverse relation between flow and the N-13 ammonia single pass extraction fraction. The uptake of N-13 ammonia was studied at myocardial blood flows ranging from 0 to 500 ml/min per 100 g, whereas physiologically occurring flows in man range only from near 0 to approximately 300 ml/min per 100 g. Within this physiologic flow range, the relation between flow and N-13 ammonia concentration was relatively linear, and a 100 percent increase in flow produced an approximately 70 percent increase in N-13 ammonia concentration.

It is concluded that N-13 ammonia is a good indicator of myocardial blood flow and compares favorably with conventional monovalent perfusion imaging agents. Positron emission computerized axial tomography permits quantitative measurements of the distribution of this agent in myocardium and therefore should prove useful in measuring regional myocardial perfusion and blood flow.

38. Schelbert, H., Phelps, M., Hoffman, E., Selin, C., Huang, S. and Kuhl, D.: Quantitative Assessment of Regional Myocardial Perfusion by N-13 Ammonia (NH) and Positron Computed Tomography (PCT). Circulation 57/58(2):9 (1978).

NH has been proposed as a new myocardial imaging agent. While myocardial NH concentrations were proportional to regional myocardial perfusion (MPR) under low flow conditions such a relationship has not been demonstrated yet in the high flow range. Therefore, the myocardial uptake of NH during hyperemia and its suitability for estimating MPR by PCT was examined. In 4 open chest dogs with control MPR of 100.2 ± 26.8 ml/min/100 gm flow was increased up to 4 fold by papaverine injected into the left circumflex coronary artery. NH and radioactive microspheres (8 μ) were injected into the left atrium, the dogs sacrificed 2 min later and tissue samples counted. NH concentrations increased in proportion to MPR (determined by the microsphere technique); for an increase in MPR by 100%, 200% and 300% NH concentrations increased by 72.9%, 125.5% and 156.8%. In 8 additional dogs myocardial NH concentrations during control and hyperemia were determined noninvasively by PCT and expressed in cpm/cm²/mCi. When compared to MPR the same relationship was found; as MPR was raised by 100%, 200% and 300%, NH cpm/cm²/mCi increased by 70.9%, 121.1% and 150.6%. We conclude that 1) myocardial uptake of NH closely follows MPR, even during high flow states, and 2) MPR can be quantitated noninvasively by PCT.

39. Schelbert, H., Phelps, M., Robinson, G., Huang, S., Hoffman, E. and Selin, C.: N-13 Ammonia for the Non-invasive Measurement of Myocardial Blood Flow. J. Nuc. Med. 20:603 (1979).

The possibility of measuring myocardial blood flow (MBF) by IV N-13 ammonia was studied in 15 open chest dogs. Myocardial extraction fraction (E) and half-times of N-13 ammonia were determined by monitoring myocardial activity following intracoronary (ic) N-13 ammonia at control, during papaverine (ic) induced hyperemia and IV infusion of isoproterenol (I) or propranolol (P). At the end of each experiment, N-13 ammonia was injected IV and radioactive microspheres into the left atrium during anterior descending coronary artery occlusion and circumflex hyperemia while arterial blood was withdrawn. The animals were sacrificed and myocardial tissue activities determined. E averaged 0.81 ± 0.06 SD at flows of 100 ml/min/100 gm and was not significantly altered by I or P. Control half-times averaged 220 min and were not affected by I or P (160 and 320 min; NS). Employing the arterial reference technique, N-13 ammonia underestimated MBF determined by microspheres.

40. Schelbert, H.R., Schuler, G., Ashburn, W.L. and Covell, J.W.: Time-Course of "Redistribution" of Thallium-201 Administered During Transient Ischemia. Eur. J. Nuc. Med., in press (1979).

The "redistribution" of Tl-201 administered as a single dose during treadmill exercise and monitored by external imaging may permit differentiation between transient ischemia and old myocardial infarction. The time course of this "redistribution" of Tl-201 was examined in 20

closed chest dogs instrumented with indwelling left atrial catheters and occlusive cuffs placed around the proximal left circumflex coronary artery. In 15 of the dogs, Tl-201 and Sr-85 microspheres (15 μ) were injected during transient coronary artery occlusion: Five of the dogs were sacrificed 2 min later without releasing the occlusion; five dogs were sacrificed after 30 min and five dogs after 4 h of reperfusion. Five dogs with permanent occlusion of the left circumflex coronary artery were studied 4 h after Tl-201 administration. Compared to normal myocardium Tl-201 activity in regions with >95% flow reductions was decreased by 93.3% in the five dogs sacrificed 2 min after administration. After 30 min of reperfusion this difference was 59.7% and was only 16.5% after 4 h of reperfusion. During the initial 30 min of reperfusion this change in regional distribution was due to a 22% fall in activity in normal myocardium and a 4.4 fold increase in the transiently ischemic myocardium. Activity in normal myocardium declined further by 63% from 30 to 240 min of reperfusion while activity in the transiently ischemic myocardium decreased by 15.5% although this change was statistically not significant. Thus, early "redistribution" of Tl-201 reflects active uptake of Tl-201 by transiently ischemic tissue and decrease in Tl-201 activity in normal myocardium, during late reperfusion redistribution is primarily due to a more rapid loss of Tl-201 from normal myocardium. We conclude that transient ischemia is visualized best early after stress. Imaging begun late after exercise, e.g., after 30 min, may not permit differentiation between transient ischemia and old myocardial infarction.

41. Schelbert, H.R., Wisenberg, G. and Marshall, R.C.: Assessment of Ventricular Function by Radionuclide Techniques. In Progress in Nuclear Medicine - Cardiovascular Nuclear Medicine, Righetti, A., Donath, A. and Serafini, A. eds., S. Karger, Basel, in press (1979).

This invited manuscript describes the current state of radionuclide techniques for the non-invasive assessment of cardiac function. It discusses the technical aspects of first pass radionuclide angiography and equilibrium blood pool imaging, compares the advantages and disadvantages of either approach and lists a number of well established applications of these techniques for the diagnosis and management of cardiac disease.

42. Schelbert, H.R., Wisenberg, G., Phelps, M.E., Gould, L., Marshall, R., Hoffman, E.J. and Kuhl, D.E.: N-13 Ammonia and Positron Emission Computed Axial Tomography for the Non-Invasive Assessment of Coronary Artery Disease in Man. Clin. Card., in press (1979).

N-13 ammonia previously has been described as an indicator of myocardial blood flow suitable for positron emission computed tomography (PCT). Previously we demonstrated the capability of N-13 ammonia and PCT for demonstrating mild, 47% diameter coronary stenosis in the experimental

animal and evaluated in this study the feasibility of this technique in man. Five normal volunteers and nine patients with arteriographically documented coronary artery disease were studied at control and during dipyridamole induced coronary vasodilation. In the normals, left ventricular N-13 ammonia activity was uniform on the cross-sectional images at control and was not altered by hyperemia. By contrast, eight of the nine patients with coronary artery disease - five with single vessel disease - developed new or more extensive defects on the hyperemic images. Further, on the images obtained during hyperemia the regional myocardial N-13 ammonia concentrations were inversely related to the degree of coronary artery stenosis. We conclude that this new technique is highly suitable for the non-invasive detection of coronary artery disease and may permit quantification of myocardial blood flow and of the severity of coronary artery stenosis.

43. Taplin, G.V. and Chopra, S.K.: Inhalation Lung Imaging with Radioactive Aerosols and Gases. Prog. Nucl. Med. 5:119-143 (1978).

Lung imaging procedures, performed after the inhalation of ^{99m}Tc Technetium labeled aerosols, ^{133}Xe and ^{81m}Kr Krypton gases, were used to visualize the sites of airway obstruction and regional abnormalities of ventilatory function in normal volunteers, patients with obstructive airway disease and pulmonary embolism suspects. This chapter presents the intercomparisons of these three methods regarding their functional significance, diagnostic merits, and limitations. A new nebulizer-radioaerosol delivery system is described. Test agent kits are inexpensive and readily available for on site assembly. Currently, we consider radioaerosol imaging in multiple views as more informative and suitable for routine use than xenon methods to detect regional abnormalities of the airways and ventilatory function. The krypton procedure is preferred in pulmonary embolism suspects because it requires far less patient cooperation than the xenon and aerosol methods and the lung images disclose regional ventilatory impairment quickly and accurately. However, krypton gas is cyclotron-produced and not yet commercially available.

44. Taplin, G.V. and Chopra, S.K.: Lung Perfusion-Inhalation Scintigraphy in Obstructive Airway Disease and Pulmonary Embolism. Radiologic Clinics of North America 16:491-513 (1978).

A perfusion examination should be performed first to image all segments of the lung adequately, i.e. in the anterior and posterior and in the right and left anterior and posterior oblique projections. Normal images exclude the diagnosis of pulmonary embolism except for microemboli.

Lung images must be interpreted in the light of high quality chest roentgenograms obtained the same day to exclude obvious nonembolic causes of regional ischemia (tumors, cysts, abscesses, bullous disease, etc.).

When perfusion defects coincide with roentgenographic abnormalities of possible embolic origin, the functional diagnosis is indeterminate and nuclear venography should be performed prior to angiography.

When P/V imaging, chest roentgenography and nuclear venography are performed and interpreted properly a correct diagnosis of embolism can be made without angiography in approximately 80% of all cases of suspected pulmonary embolism.

Angiography is indicated in indeterminate cases when the venogram is negative, heparin treatment is contraindicated, and/or venacaval surgery is contemplated.

Pulmonary embolism remains a difficult diagnostic problem and more correlative V/P imaging, venographic and angiographic data are needed to determine the validity of nuclear imaging procedures for detecting emboli occluding lobar, segmental and subsegmental vessels.

45. Taplin, G.V. and Chopra, S.K.: Ventilation-Perfusion Lung Imaging in Diaphragmatic Paralysis. Southern Medical Journal, Journal of the Southern Medical Association 72:351-353 (1979).

Decreased respiratory function in the supine position is most commonly related to left ventricular failure, obesity, severe obstructive pulmonary disease, or to abdominal diseases which restrict diaphragmatic motion. Neurologic causes of diaphragmatic paralysis are rare.

This report describes the clinical history, physical findings, and results of chest roentgenography, arterial blood gas (ABG) determinations, pulmonary function test (PFT) findings, and the results of V/P lung imaging in a patient with diaphragmatic paralysis.

46. Taplin, G.V., Chopra, S.K., Tashkin, D.P. and Elam, D.: Lung Clearance of Soluble Radioaerosols of Different Molecular Weights in Systemic Sclerosis. Thorax 34:63 (1979).

Clearance rates of soluble radioaerosols of sodium pertechnetate ($^{99m}\text{TcO}_4$; mol wt 163) and diethylenetriaminepenta-acetate ($^{99m}\text{Tc-DTPA}$; mol wt 492) were determined in seven normal subjects and ten patients with systemic sclerosis affecting the lungs. Twenty millicuries (mCi) each of $^{99m}\text{TcO}_4$ and $^{99m}\text{Tc-DTPA}$ in 5 ml saline were aerosolized and inhaled using a disposable "Blount" nebulizer on two different days. Two regions of interest over each posterior lung field were monitored with a scintillation camera, and data were stored on magnetic tape using a Hewlett Packard Data Analyser. Decreasing levels of radioactivity were plotted semilogarithmically and half-time ($T_{1/2}$) removal rates were calculated. The $T_{1/2}$ values in normal subjects did not differ significantly from $T_{1/2}$ values of the patients with TcO_4 . However, the removal rates of the higher molecular weight solute were significantly faster from lower lung zones in patients with systemic sclerosis than in the normal subjects.

The faster absorption of DTPA from lower lung zones of the patients could be due to regional abnormalities of alveolar epithelium at the lung bases, presumably as a result of greater retractive forces secondary to fibrosis.

47. Taplin, G.V., Chopra, S.K., Tashkin, D.P., Trevor, E. and Elam, D.: Imaging Sites of Airway Obstruction and Measuring Functional Response to Bronchodilator Therapy in Asthma. Thorax 34 (1979).

This study was conducted to localize the site(s) of airway obstruction by inhalation lung imaging in twelve stable asthmatic patients. The changes in image patterns with terbutaline treatment administered in a double blind fashion were correlated with pulmonary function tests. Inhaled terbutaline decreased airway resistance and improved radioaerosol images in nine (75%) and Xenon images in five (42%) patients. Subcutaneously injected terbutaline improved airway resistance and aerosol images in eleven (91%) and Xenon images in eight (67%). In conclusion, inhaled bronchodilator had its predominant action on the central airways whereas injected drug relieved obstruction involving both the central and peripheral airways.

48. Taplin, G.V., Chopra, S.K., Trevor, E. and Tashkin, D.P.: Sites of Airway Dilatation in Asthma Following Inhaled Versus Subcutaneous Terbutaline: Comparison of Physiologic Tests with Radionuclide Lung Images. The American Journal of Medicine, in press (1979).

In 12 asthmatic subjects we compared the relative magnitude and sites of airway dilatation of a beta-adrenergic stimulant administered by different routes. Physiologic tests considered to reflect changes in the caliber of central or peripheral airways and radioaerosol and radio-xenon lung imaging were performed before and after aerosolized terbutaline (0.5 mg), subcutaneous terbutaline (0.5 mg) or placebo. Placebo caused little change in lung function or lung imaging. After inhaled terbutaline, large and small airway function improved in 7 and 0 subjects, respectively, and radioaerosol and xenon images showed improvement in 9 and 5 subjects, respectively. After subcutaneous terbutaline, large and small airway function both improved in 10 subjects and radioaerosol and xenon images showed improvement in 11 and 8 subjects, respectively. These findings are consistent with the action of inhaled terbutaline mainly on large airways and of subcutaneous terbutaline on both large and small airways.

49. Taplin, G.V., Hayes, M., Chopra, S.K., Knox, D. and Elam, D.: Improved Radioaerosol Administration System for Routine Inhalation Lung Imaging. Radiology 131:256-258 (1979).

An improved radioaerosol administration system has been developed to reduce the number of droplets larger than 2.0 μ m in diameter which

caused abnormal hyperdeposition of inhaled aerosols in the large airways. The new system has achieved this goal by interposing a reservoir-settling bag in the aerosol delivery line between the nebulizer and the patient. The components are inexpensive, commercially available and easily assembled in any nuclear medicine service.

50. Wisenberg, G., Schelbert, H., Robinson, G., Selin, C., Hoffman, E. and Phelps, M.: Quantitation of Regional Myocardial Blood Flow by Positron Emission Computerized Transaxial Tomography. J. Nuc. Med. 20:648 (1979).

Positron emission computerized transaxial tomography (PCT) offers the potential of measuring non-invasively tissue concentrations of radioactive indicators, but this has yet to be established for the heart. Also, count recovery is affected by object size and may be limited in small structures, e.g., myocardium. Therefore, the potential of PCT for non-invasive quantitation of regional myocardial blood flow (RMBF) was studied in 7 open chest dogs, with 30 imaging procedures and 2 planes/study. Ungated PCT imaging was begun 30 sec after microspheres (8-15 μ) labeled with Cu-62 ($t_{1/2}$ =9.7 min, positron emitting) were injected together with gamma microspheres (9 μ) into the left atrium. Following control study, subsequent images were obtained after repeat injections of both microspheres while circumflex flow was altered from 9 to 464 ml/min/100 gm. After sacrifice, myocardial tissue samples were counted for gamma activity, RMBF determined by the arterial reference technique and compared to RMBF calculated from regions-of-interest in the PCT images with cpm/cm² converted to ct/gm by a calibration factor, and to ml/min/100 gm using the reference sample. Based on phantom studies, corrections were made for dependence of count recovery on wall thickness, as measured by *in vivo* echocardiography. Uncorrected PCT RMBG correlated poorly with *in vitro* RMBF, while data corrected for wall thickness correlated linearly and in a one to one relationship by $y=5.25+1.06x$ ($r=0.85$) and by $y=16.0+97x$ $n=60$ ($r=0.95$) for the anterior and posterior LV wall regions respectively. The results indicate that PCT accurately measures myocardial indicator concentration when corrections are made for object size. With further developments, non-invasive measurement of myocardial flow and metabolism by PCT is feasible.

**STAFF
RECOGNITION
AND
HONORS**

STAFF RECOGNITION AND HONORS

Wade L. Berry

Editorial Board
Journal of Plant Nutrition

Jean S. de Vellis

Invited Speaker
Twenty-second Symposium
California Branch of the Tissue Culture
Association, Los Angeles, California
Mental Retardation Research Center
UCLA
Department of Pharmacology
UCLA
Department of Neuropathology
Stanford University
Department of Medicine
UC San Francisco and Veteran's
Administration Hospital, San Francisco
Twelfth Annual Winter Conference on
Brain Research
Sun Valley, Idaho
Seventh International Congress of
Pharmacology
Paris, France
Tenth Annual Meeting
American Society for Neurochemistry
Charleston, South Carolina
Sixty-third Annual Meeting
Society for Pharmacology and Experimental
Therapeutics
Dallas, Texas
Interview Series
Global Television KSCI
Los Angeles, California

Program Project Site Visit for NIH

Armand J. Fulco

Invited Speaker
Symposium on the Regulation of Membrane
Fluidity
XI International Congress of Biochemistry

Armand J. Fulco (Continued)

Invited Speaker
Chemistry-Biochemistry
California State University, Long Beach

Editorial Board
Journal of Bacteriology

Esther F. Hays

Invited Speaker
Cleveland Clinic Conference

Acting Assistant Dean (April-October 1979)
UCLA School of Medicine

Harvey R. Herschman

Director for Research Support and Research
Core Services
UCLA Jonsson Comprehensive Cancer Center

Member
Molecular Biology Institute
UCLA

Editorial Board
Brain Research

Ad Hoc Study Section
Cell Biology, NIH

Reviewer
National Science Foundation
National Foundation (March of Dimes)
Huntington's Chorea Foundation

Invited Speaker
Canadian Clinical Chemistry Society
Montreal, Canada
Washington University
St. Louis, Missouri
University of Minnesota
St. Paul, Minnesota
U.C. Irvine
U.C. Berkeley

Edward J. Hoffman

Georg von Hevesy Prize
Second International Congress of the
World Federation of Nuclear Medicine
and Radiation Biology
Washington, D.C.

David E. Kuhl

Fellow
Council on Circulation
American Heart Association

Herman L. Blumgart Award
New England Chapter
Society of Nuclear Medicine

John Hershman Memorial Lecturer
Eastern Association of Electroencephalo-
graphers

James F. Mead

Editorial Board

Lipids

Journal of Neurochemistry

Physiological Chemistry and Physics

Progress in the Chemistry of Fats and
Other Lipids

AGE

Invited Speaker

Symposium on Health Effects of Nitrogen
Oxides

ACS-CSJ Meeting
Honolulu, Hawaii

Symposium on Oxygen, Biochemical and
Clinical Aspects
Colorado State University

Clinical Correlation Lectures
UC Irvine

Session Chairman
Deuel Lipid Conference
Carmel, California

Lawrence S. Myers, Jr.

Chairman

Advisory Committee for the Center for
Fast Kinetics Research
University of Texas at Austin
Annual Meeting Site Selection and
Policy Committee
Radiation Research Society

Secretary and Chairman-Elect
Advisory Board
Radiation Chemistry Data Center
University of Notre Dame

Member
Travel Application Review Committee
6th International Congress on Radiation
Research
Tokyo, Japan

Invited Speaker
United States-Italy Cooperative Seminar
on Radiation Sensitivity: Facts and
Models
Rome, Italy

Interview
Nuclear Energy Debate
Voice of America

Hideo Nishita

Invited Review
Chapter for CRC Handbook

Park S. Nobel

Editorial Board
Plant Physiology

Co-Editor
Plant Physiological Ecology (3 vols.)

Invited Speaker
Heat and Water Stress Binational Conference
Stanford, California
Ecological Adaptation Symposium
Athens, Georgia

Michael D. Phelps

Georg von Hevesy Prize
Second International Congress of the
World Federation of Nuclear Medicine
and Radiation Biology
Washington, D.C.

Certificate of Excellence
IX International Meeting on Cerebral
Blood Flow, Metabolism and Function
Tokyo, Japan

Anthony Ricci

Sixth Annual Ralph and Marjorie Crump
Prize

Evan M. Romney

Member
U.S. Department of Energy Shallow Land
Burial Steering Committee

Heinz Schelbert

Georg von Hevesy Prize
Second International Congress of the
World Federation of Nuclear Medicine
and Radiation Biology
Washington, D.C.

Arthur Wallace

Session Chairman
Micronutrient Workshop
National Research Center of Egypt and
The Institute for Technical Cooperation
of the Federal Republic of Germany
Workshop on Applications of Science and
Technology for Desert Development
Egypt

Special Consultant
Arab Development Institute
Libya

Consultant and Seminar
Department of Agronomy
University of Nebraska
Brigham Young University and Benson
Institute of Food and Agriculture

Invited Review
Effect of Soil pH on Plant Composition
CRC Press

Arthur Wallace (Continued)

**Invited Keynote Speaker
International Symposium on Energy and
the Ecosystem
Grand Forks, North Dakota**

INDEX OF ABSTRACTS

	PAGE NO.
ALEXANDER, GEORGE V.	
Influence of Phosphorus on Zinc, Iron, Manganese and Copper Uptake By Plants	66
Mineral Composition of <u>Cuscuta nevadensis</u> Johnston (Dodder) In Relationship To Its Hosts	68
Trace Elements in Seafood Organisms Around Southern California Municipal Wastewater Outfalls	71
BERRY, MADE L.	
Accumulation of Trace Elements By A Population of Corn Plants During A Simultaneous Acute Exposure	63
Further Development of the Use of Wastewater for Hydroponic Crop-Culture	45
Interactions of Environmental Factors	45
Nutrient Content of Lettuce Grown Under Specified Conditions in Six Controlled-Environment Facilities.	44
Uniformity Studies with Lettuce: Results of Growth and Tissue Analysis	45
Wastewater as a Hydroponic Growth Medium for Greenhouse Crop Culture	67
CHOPRA, SAWTANTRA K.	
Imaging Sites of Airway Obstruction and Measuring Functional Response to Bronchodilator Therapy in Asthma	100
Improved Radioaerosol Administration System for Routine Inhalation Lung Imaging	100
Inhalation Lung Imaging with Radioactive Aerosols and Gases	98
Lung Clearance of Soluble Radioaerosols of Different Molecular Weights in Systemic Sclerosis	99
Lung Perfusion-Inhalation Scintigraphy in Obstructive Airway Disease and Pulmonary Embolism	98
Sites of Airway Dilatation in Asthma Following Inhaled Versus Subcutaneous Terbutaline: Comparison of Physiologic Tests with Radionuclide Lung Images	100
Ventilation-Perfusion Lung Imaging in Diaphragmatic Paralysis	99

	PAGE NO.
DHOPESHMARKAR, GOVIND A.	
Dietary Eggs and Changes in Plasma, Liver and Brain Lipids	13
Lipogenesis in the Developing Brain: Utilization of Radioactive Leucine, Isoleucine, Octanoic Acid and β -Hydroxybutyric Acid	15
Metabolism of All <u>trans</u> 9,12-[1- 14 C]Octadecadienoic Acid in the Developing Brain	24
Trans Fatty Acids: Positional Specificity in Brain Lecithin	25
de VELLIS, JEAN S.	
Cellular Interactions Cause β -Adrenergic Receptor Uncoupling from Adenylate Cyclase	14
Cellular Interactions Uncouple β -Adrenergic Receptors from Adenylate Cyclase	15
Glucocorticoid Regulation in Rat Brain Cell Cultures. Hydrocortisone Increases the Rate of Synthesis of Glycerol Phosphate Dehydrogenase in C6 Glioma Cells	29
Glycerol-3-phosphate Dehydrogenase Isoenzymes in Human Tissues: Evidence for a Heart-specific Form	30
Hormonal Patterns of the Hypothalamo-Pituitary-Gonadal Axis in the Rat During Postnatal Development and Sexual Maturation	22
Immunologically and Biochemically Distinct Forms of Glycerol Phosphate Dehydrogenase (GPDH) in Human Heart	30
Peptidases in the Rat Hypothalamus Inactivating Gonadotropin-Releasing Hormone (Gn-RH)	23
Preparation of Separate Astroglial and Oligodendroglial Cell Cultures	27
Regulation of β -Adrenergic Agonist, PGE ₁ and Adenosine Increased cAMP Levels by α -Adrenergic Agonists in Primary Glial Cultures	28
Regulation of Cyclic GMP, Cyclic AMP and Lactate Dehydro- genase by Putative Neurotransmitters in the C6 Rat Glioma Cell Line	14
Sequence Complexity of Polyadenylated RNA Obtained from Rat Brain Regions and Cultured Rat Cells of Neural Origin	24

	PAGE NO.
de VELLIS, JEAN S. (continued)	
The Regulation of Adenosine 3' : 5'-Cyclic Monophosphate Accumulation in Glia by Alpha-Adrenergic Agonists	29
EDNEY, ERIC B.	
Ecological Effects of Precipitator Ash on Desert Plants and Animals	49
The Distribution and Abundance of Soil Arthropods in the Northern Mojave Desert	60
FULCO, ARMAND J.	
Adaptive Regulation of Membrane Lipid Biosynthesis in Bacilli by Environmental Temperature	14
Formation of 9,10-Epoxy palmitate and 9,10-Dihydroxy palmitate from Palmitoleic Acid by a Soluble System from <u>Bacillus Megaterium</u>	17
HARARY, ISAAC M.	
Biochemistry of Cardiac Development: <u>In Vivo</u> and <u>In Vitro</u> Studies	17
Lysine-Rich Histones and the Selective Digestion of the Globin Gene in Avian Red Blood Cells	39
HAYS, ESTHER F.	
AKR Murine Leukemia Viruses and Long-Term Bone Marrow Cultures from AKR and SJL Mice	20
Cell Surface Proteins of Normal and Malignant Human Leukocytes: Homology with Envelope Proteins of Mammalian, C-Type Retroviruses	38
Changes in Cell Surface Glycoprotein, gp70, During AKR Thymic Lymphoma	38
Factors Promoting Colony Stimulating Activity (CSA) Production in Macrophages and Epithelial Cells	35
Gross Murine Leukemia Virus-Induced Alterations in the Thymus of Preleukemic AKR Mice	12
Influence of Thymic Epithelium on Colony Formation by AKR Mouse Thymocytes	18
Interactions of Thymic Epithelial Cells, Lymphocytes and Murine Leukemia Viruses	18

	PAGE NO.
HAYS, ESTHER F. (continued)	
Lack of Correlation Between Expression of "Amphotropic" MuLV and Oncogenicity	13
Lipid Mobilization in Lymphoma-Bearing Mice	27
Oncogenicity of AKR Endogenous Leukemia Viruses	34
HERSCHMAN, HARVEY R.	
Characterization of Metallothionein in a Human Cell Line	35
Cholera Toxin Stimulates Division of 3T3 Cells	34
Dexamethasone Stimulation of Metallothionein Synthesis in HeLa Cell Cultures	24
Identification and Characterization of a Brain-Specific Antigen Enriched in Neonatal Brain: II. Antigenic Stability, Species Cross-reactivity and Tumor Cell Association	37
Metallothionein Accumulation in Response to Cadmium in a Clonal Rat Liver Cell Line	35
Mitogenic Response to Epidermal Growth Factor Relationship to Number, Affinity and Down Regulation of EGF Receptors in Three Murine Embryo Cell Lines	12
Mitogens for Murine Embryo Cell Lines	21
Nerve Growth Factor Mediated Induction of Tyrosine Hydroxylase in a Clonal Pheochromocytoma Cell Line	17
New Neural Cell Lines Derived from Experimentally Induced Rat Tumors and from Human Neuroblastomas	22
Pheochromocytoma Cell Lines as Models of Growth Factor and Hormonally Induced Neuronal Differentiation	17
Prostatic Acid Phosphatase and Prostatic Cancer	15
Radioimmunoassay for Serum Prostatic Acid Phosphatase and the Detection of Prostatic Cancer	20
The Detection of Prostatic Cancer by Radioimmunoassay: A Review	16
The Measurement of Prostatic Acid Phosphatase in Various Cell Lines	16
The Response of HeLa Cells to Cadmium and Zinc	36

HOFFMAN, EDWARD J.

PAGE NO.

Can N-13 Ammonia be Used as a Cerebral Blood Flow Tracer?	90
Design and Performance Characteristics of the ECAT Positron Tomograph	86
Design Considerations in Positron Computed Tomography (PCT)	86
ECG Gating in Positron Emission Computed Tomography	80
Effect of Accidental Coincidence in Positron Emission Computed Tomography	79
Emission Computed Tomography: A New Technique for the Quantitative Physiologic Study of Brain and Heart <u>In Vivo</u>	87
Emission Computed Tomography with Positrons	79
Investigation of 18-F-2-Deoxyglucose for the Measure of Myocardial Glucose Metabolism	87
N-13 Ammonia and Positron Emission Computed Axial Tomography for the Non-Invasive Assessment of Coronary Artery Disease in Man	97
N-13 Ammonia for the Non-Invasive Measurement of Myocardial Blood Flow	96
Non-Invasive Assessment of Coronary Stenosis with Myocardial Perfusion Imaging During Pharmacologic Coronary Vasodilation. V. Detection of 47% Diameter Coronary Stenosis with Intravenous Nitrogen-13 Ammonia and Emission-Computed Tomography in Intact Dogs	76
Optimization of System Design Parameters for Emission Computed Tomography	30
Physiologic Tomography Measure of Cerebral and Myocardial Metabolic Rate for Glucose (MRglc): Models and Measurement Optimization	91
Physiologic Tomography of Myocardial Glucose Metabolism, Perfusion and Blood Pools with Multiple Gated Acquisition	91
Quantitation in Positron Emission Computed Tomography: 1. Effect of Object Size	79
Quantitation of Regional Myocardial Blood Flow by Positron Emission Computerized Transaxial Tomography	101
Quantitative Assessment of Regional Myocardial Perfusion by N-13 Ammonia (NH) and Positron Computed Tomography (PCT)	95
Regional Myocardial Perfusion Assessed by N-13 Labeled Ammonia and Positron Emission Computerized Axial Tomography	95

HOFFMAN, EDWARD J. (continued)

Relationship of Local Cerebral Glucose Utilization and Relative Perfusion in Stroke and Epilepsy: Determination by Emission Computed Tomography of Fluorine-18 Fluorodeoxyglucose and Nitrogen-13 Ammonia	84
Sampling Requirements of Emission Computed Tomographic (ECT) Scanners	81
Single Pass Extraction of N-13 Ammonia by Myocardium and Its Relationship to Myocardial Blood Flow	81
The [¹⁸ F]Fluorodeoxyglucose Method for the Measurement of Local Cerebral Glucose Utilization in Man	92
Tomographic Measure of Local Cerebral Metabolic Rate for Glucose (LCMRGLc) in Man with 2(F-18)Fluoro-Deoxyglucose (FDG): Validation of Method	88
Tomographic Measurement of Cerebral Blood Volume with C-11 Labeled Carboxyhemoglobin	88
Tomographic Measurement of Regional Cerebral Glucose Metabolic Rate in Man with (¹⁸ F) Fluorodeoxyglucose: Validation of Method	89
Validation of the Noninvasive Tomographic Measure of Regional Cerebral Glucose Metabolism in Man with ¹⁸ F-2-Fluoro-2-Deoxyglucose	90
HUANG, SUNG-CHENG	
Can N-13 Ammonia be Used as a Cerebral Blood Flow Tracer?	90
Design and Performance Characteristics of the ECAT Positron Tomograph	86
Design Considerations in Positron Computed Tomography (PCT)	86
Effect of Accidental Coincidence in Positron Emission Computed Tomography	79
Emission Computed Tomography: A New Technique for the Quantitative Physiologic Study of Brain and Heart <u>In Vivo</u>	87
Investigation of 18-F-2-Deoxyglucose for the Measure of Myocardial Glucose Metabolism	87
N-13 Ammonia for the Non-Invasive Measurement of Myocardial Blood Flow	96
Optimization of System Design Parameters for Emission Computed Tomography	80

HUANG, SUNG-CHENG (continued)

Physiologic Tomography Measure of Cerebral and Myocardial Metabolic Rate for Glucose (MRGlc): Models and Measurement Optimization	91
Physiologic Tomography of Myocardial Glucose Metabolism, Perfusion and Blood Pools with Multiple Gated Acquisition	91
Quantitation in Positron Emission Computed Tomography: 1. Effect of Object Size	79
Quantitative Assessment of Regional Myocardial Perfusion by N-13 Ammonia (NH) and Positron Computed Tomography (PCT)	95
Regional Myocardial Perfusion Assessed by N-13 Labeled Ammonia and Positron Emission Computerized Axial Tomography	95
Sampling Requirements of Emission Computed Tomographic (ECT) Scanners	81
Single Pass Extration of N-13 Ammonia by Myocardium and Its Relationship to Myocardial Blood Flow	31
Tomographic Measure of Local Cerebral Metabolic Rate for Glucose (LCMRGlc) in Man with 2(F-18) Fluoro-Deoxyglucose (FDG): Validation of Method	88
Tomographic Measurement of Cerebral Blood Volume with C-11 Labeled Carboxyhemoglobin	88
Tomographic Measurement of Regional Cerebral Glucose Metabolic Rate in Man with (18F) Fluorodeoxyglucose: Validation of Method	89
Validation of the Noninvasive Tomographic Measure of Regional Cerebral Glucose Metabolism in Man with 18F-2-Fluoro-2-Deoxyglucose	90

HUNTER, RICHARD B.

Nitrogen Cycle in the Northern Mojave Desert: Implications and Predictions	69
Plant Response to Nitrogen Fertilization in the Northern Mohave Desert and Its Relationship to Water Manipulation	59

KAY, ERNEST

Differences in the Circular Dichroism Spectra of Eu- and Heterochromatin Fractions from Rat Liver	32
---	----

	PAGE NO.
KAY, ERNEST (continued)	
Lima Bean Proteinase Inhibitor	26
Oxidation of Bases Within Double-Stranded DNA by Radiolysis of Anoxic Bromide Solutions	33
Radiolysis of DNA and Proteins	33
Structure-Function Relationships of Proteinase Inhibitors from Soybean (Bowman-Birk) and Lima Bean	25
KUHL, DAVID E.	
Can N-13 Ammonia Be Used as a Cerebral Blood Flow Tracer?	90
Design and Performance Characteristics of the ECAT Positron Tomograph	86
Design Considerations in Positron Computed Tomography (PCT)	86
ECG Gating in Positron Emission Computed Tomography	80
Effect of Accidental Coincidence in Positron Emission Computed Tomography	79
Emission Computed Tomography: A New Technique for the Quantitative Physiologic Study of Brain and Heart <u>In Vivo</u>	87
Epileptic Patterns of Local Cerebral Metabolism and Perfusion in Man: Investigation by Emission Computed Tomography of ¹⁸ F-Fluorodeoxyglucose and ¹³ N-Ammonia	83
Investigation of ¹⁸ F-2-Deoxyglucose for the Measure of Myocardial Glucose Metabolism	87
Labeled 2-Deoxy-D-Glucose Analogs. ¹⁸ F-Labeled 2-Deoxy-2-Fluoro-D-Glucose	82
Local Cerebral Blood Volume Response to Carbon Dioxide in Man	77
Local Cerebral Blood Volume Response to Carbon Dioxide in Man	77
Methotrexate-Induced Ventriculitis: Appearance on Routine Radionuclide Scan and Emission Computed Tomography	86
N-13 Ammonia and Positron Emission Computed Axial Tomography for the Non-Invasive Assessment of Coronary Artery Disease in Man	97
Optimization of System Design Parameters for Emission Computed Tomography	80

KUHL, David E.

Patterns of Local Cerebral Metabolism and Perfusion in Partial Epilepsy by Emission Computed Tomography of ^{18}F -Fluoro-Deoxy-glucose and ^{13}N -Ammonia	84
Physiologic Tomography Measure of Cerebral and Myocardial Metabolic Rate for Glucose (MRGlc): Models and Measurement Optimization	91
Physiologic Tomography of Myocardial Glucose Metabolism, Perfusion and Blood Pools with Multiple Gated Acquisition	91
Quantitative Assessment of Regional Myocardial Perfusion by N-13 Ammonia (NH) and Positron Computed Tomography (PCT)	95
Regional Myocardial Perfusion Assessed by N-13 Labeled Ammonia and Positron Emission Computerized Axial Tomography	95
Relationship of Local Cerebral Glucose Utilization and Relative Perfusion in Stroke and Epilepsy: Determination by Emission Computed Tomography of Fluorine-18 Fluorodeoxy-glucose and Nitrogen-13 Ammonia	84
Sampling Requirements of Emission Computed Tomographic (ECT) Scanners	81
Single Pass Extraction of N-13 Ammonia by Myocardium and Its Relationship to Myocardial Blood Flow	81
The [^{18}F]Fluorodeoxyglucose Method for the Measurement of Local Cerebral Glucose Utilization in Man	92
The Pathophysiology of Acute Severe Brain Swelling Following Pediatric Head Trauma	73
The Pathophysiology, Treatment and Outcome Following Severe Head Injury in Children	75
Tomographic Measure of Local Cerebral Metabolic Rate for Glucose (LCMRGlc) in Man with 2(F-18)Fluoro-Deoxyglucose (FDG): Validation of Method	88
Tomographic Measurement of Cerebral Blood Volume with C-11 Labeled Carboxyhemoglobin	88
Tomographic Measurement of Regional Cerebral Glucose Metabolic Rate in Man with (^{18}F) Fluorodeoxyglucose: Validation of Method	89
Validation of the Noninvasive Tomographic Measure of Regional Cerebral Glucose Metabolism in Man with ^{18}F -2-Fluoro-2-Deoxyglucose	90

	PAGE NO.
LEWIS, HAZEL L.	
On the Mechanism of 5-Bromouracil Radiosensitization	40
Serologic Assay of DNA Base Damage. I. 5-Hydroxymethyl- deoxyuridine, A Radiation Product of Thymidine	27
LINDBERG, ROBERT G.	
An Overview of Solar Thermal Electric Systems, Environ- mental Issues	49
LUNT, OWEN R.	
Further Development of the Use of Wastewater for Hydroponic Crop-Culture	45
Wastewater as a Hydroponic Growth Medium for Greenhouse Crop Culture	67
MAC DONALD, NORMAN S.	
Enzymatic Synthesis of C-11 Pyruvic Acid and C-11 L-Lactic Acid	75
Evaluation of Left Ventricular Function (Ejection Fraction and Segmental Wall Motion) by Single Pass Radioisotope Angiography	82
Investigation of 18-F-2-Deoxyglucose for the Measure of Myocardial Glucose Metabolism	87
Relationship of Local Cerebral Glucose Utilization and Relative Perfusion in Stroke and Epilepsy: Determination by Emission Computed Tomography of Fluorine-18 Fluro- deoxyglucose and Nitrogen-13 Ammonia	84
MC GINNIS, JAMES F.	
Glucocorticoid Regulation in Rat Brain Cell Cultures. Hydro- cortisone Increases the Rate of Synthesis of Glycerol Phosphate Dehydrogenase in C6 Glioma Cells.	29
Glycerol-3-phosphate Dehydrogenase Isoenzymes in Human Tissues: Evidence for a Heart-specific Form.	30
Immunologically and Biochemically Distinct Forms of Glycerol Phosphate Dehydrogenase (GPDH) in Human Heart	30
MEAD, JAMES F.	
Autoxidation of Fatty Acid Monolayers Adsorbed on Silica Gel. III. Effects of Saturated Fatty Acids and Cholesterol	40

MEAD, JAMES F. (continued)

Autoxidation of Fatty Acid Monolayers Adsorbed on Silica Gel IV. Effects of Antioxidants	27
Dietary Eggs and Changes in Plasma, Liver and Brain Lipids	13
Epoxides as Products of Lipid Autoxidation in Rat Lungs	36
Formation and Metabolism of Cholesterol Epoxide in Rat Lung	37
Initiation of Peroxidation by NO ₂ in Natural and Model System:	31
Lipid Mobilization in Lymphoma-Bearing Mice	27
Lipid Peroxidation in Model and Natural Membranes	31

MYERS, LAWRENCE S., JR.

Free Radical Damage of Nucleic Acids and Their Components: The Direct Absorption of Energy	32
Oxidation of Bases Within Double-Stranded DNA by Radiolysis of Anoxic Bromide Solutions	33
Radiolysis of DNA and Proteins	33

NAGY, KENNETH A.

Aspects of Dietary Quality, Nutrient Assimilation and Water Balance in Wild Howler Monkeys (<u>Alouatta palliata</u>)	50
Endocrine Function and Reproductive Impairment in an Irradiated Population of the Lizard <u>Uta stansburiana</u>	54
Energetics, Temperature and Water Relations in Winter Aggregated <u>Sceloporus Jarrovi</u> (Sauria: Iguanidae)	47
Energy Metabolism and Food Consumption by Wild Howler Monkeys (<u>Alouatta palliata</u>)	51

NISHITA, HIDEO

Effect of Fulvic and Humic Acids and Inorganic Phase of Soil on the Sorption and Extractability of ²³⁹ Pu(IV)	51
Radionuclide Uptake by Plants	52
Some Factors That Influence the Extractability of ²³⁹ Pu(IV) from Several Clay Minerals	52

NOBEL, PARK S.

Effect of Water Stress on the Temperature Optima of Net CO ₂ Exchange for Two Desert Species	54
--	----

NOBEL, PARK S. (continued)

Environmental Influences on Open Stomates of A Crassulacean Acid Metabolism Plant, <u>Agave deserti</u>	53
Leaf Anatomy and Water-Use Efficiency	52
Salinity Effects on Leaf Anatomy. Consequences for Photosynthesis	50
Surface Temperature of Cacti - Influences of Environmental and Morphological Factors	53

PHELPS, MICHAEL E.

Can N-13 Ammonia Be Used as a Cerebral Blood Flow Tracer?	90
Design and Performance Characteristics of the ECAT Positron Tomograph	86
Design Considerations in Positron Computed Tomography (PCT)	86
ECG Gating in Positron Emission Computed Tomography	80
Effect of Accidental Coincidence in Positron Emission Computed Tomography	79
Emission Computed Tomography: A New Technique for the Quantitative Physiologic Study of Brain and Heart <u>In Vivo</u>	87
Emission Computed Tomography with Positrons	79
Epileptic Patterns of Local Cerebral Metabolism and Perfusion in Man: Investigation by Emission Computed Tomography of 18F-Fluorodeoxyglucose and 13N-Ammonia	83
Investigation of 18-F-2-Deoxyglucose for the Measure of Myocardial Glucose Metabolism	87
N-13 Ammonia and Positron Emission Computed Axial Tomography for the Non-Invasive Assessment of Coronary Artery Disease in Man	97
N-13 Ammonia for the Non-invasive Measurement of Myocardial Blood Flow	96
Non-Invasive Assessment of Coronary Stenosis with Myocardial Perfusion Imaging During Pharmacologic Coronary Vasodilation. V. Detection of 47% Diameter Coronary Stenosis with Intravenous Nitrogen-13 Ammonia and Emission-Computed Tomography in Intact Dogs	76
Optimization of System Design Parameters for Emission Computed Tomography	80

PHELPS, MICHAEL E. (continued)

Patterns of Local Cerebral Metabolism and Perfusion in Partial Epilepsy by Emission Computed Tomography of ^{18}F -Fluoro-Deoxyglucose and ^{13}N -Ammonia	84
Physiologic Tomography: A New Means for the Non-Invasive Measurement of Myocardial Metabolism, Blood Flow and Function	94
Physiologic Tomography Measure of Cerebral and Myocardial Metabolic Rate for Glucose (MRGlc): Models and Measurement Optimization	91
Physiologic Tomography of Myocardial Glucose Metabolism, Perfusion and Blood Pools with Multiple Gated Acquisition	91
Quantitative Assessment of Regional Myocardial Perfusion by N-13 Ammonia (NH) and Positron Computed Tomography (PCT)	95
Quantitation in Positron Emission Computed Tomography: I. Effect of Object Size	79
Quantitation of Regional Myocardial Blood Flow by Positron Emission Computerized Transaxial Tomography	101
Regional Myocardial Perfusion Assessed by N-13 Labeled Ammonia and Positron Emission Computerized Axial Tomography	95
Relationship of Local Cerebral Glucose Utilization and Relative Perfusion in Stroke and Epilepsy: Determination by Emission Computed Tomography of Fluorine-18 Fluorodeoxyglucose and Nitrogen-13 Ammonia	84
Sampling Requirements of Emission Computed Tomographic (ECT) Scanners	81
Single Pass Extraction of N-13 Ammonia by Myocardium and Its Relationship to Myocardial Blood Flow	81
The [^{18}F]Fluorodeoxyglucose Method for the Measurement of Local Cerebral Glucose Utilization in Man	92
Tomographic Measure of Local Cerebral Metabolic Rate for Glucose (LCMRGlc) in Man with 2(F-18)Fluoro-Deoxyglucose (FDG): Validation of Method	88
Tomographic Measurement of Cerebral Blood Volume with C-11 Labeled Carboxyhemoglobin	88
Tomographic Measurement of Regional Cerebral Glucose Metabolic Rate in Man with (^{18}F) Fluorodeoxyglucose: Validation of Method	89
Validation of the Noninvasive Tomographic Measure of Regional Cerebral Glucose Metabolism in Man with ^{18}F -2-Fluoro-2-Deoxyglucose	90

	PAGE NO.
ROBINSON, GERALD D., JR.	
Cyclotron Related Radiopharmaceutical Development Program at UCLA	93
Investigation of 18-F-2-Deoxyglucose for the Measure of Myocardial Glucose Metabolism	87
N-13 Ammonia for the Non-Invasive Measurement of Myocardial Blood Flow	96
Quantitation of Regional Myocardial Blood Flow by Positron Emission Computerized Transaxial Tomography	101
Reinvestigation of the Preparation of ¹³¹ I-4-Iodoantipyrine from ¹³¹ I-Iodine	94
Relationship of Local Cerebral Glucose Utilization and Relative Perfusion in Stroke and Epilepsy: Determination by Emission Computed Tomography of Fluorine-18 Fluorodeoxyglucose and Nitrogen-13 Ammonia	84
The Zinc-62/Copper-62 Generator: A Convenient Source of Copper-62 for Radiopharmaceuticals	94
ROMNEY, EVAN M.	
Effect of Acidification of a Calcareous Soil on Yield and Mineral Composition of Three Cultivars of Cotton Grown in a Glasshouse	59
Effect of Different Rootstocks on the Nutrient Element Composition of the Scion Leaves in Citrus	70
Leaf Absorption of Metals Deposited as Dust on Leaves	68
Mineral Composition of <i>Cuscuta nevadensis</i> Johnston (Dodder) in Relationship to Its Hosts	68
Mineral Element Concentration in Leaves of Some Citrus Varieties Grown in Greece	56
Nitrogen Cycle in the Northern Mohave Desert: Implications and Predictions	69
Nitrogen Fixation by Microfloral-Higher Plant Associations in Arid to Semiarid Environments	48
Nutrient Concentrations in the Natural Vegetation of the Mohave Desert	48
Plant Response to Nitrogen Fertilization in the Northern Mohave Desert and Its Relationship to Water Manipulation	59

	PAGE NO.
ROMNEY, EVAN M. (continued)	
Radionuclide Uptake by Plants	52
Role of Synthetic Chelating Agents in Trace Metal Uptake by Plants	70
Uptake of Mineral Forms of Nitrogen by Desert Plants	69
SCHELBERT, HEINZ R.	
Assessment of Ventricular Function by Radionuclide Techniques.	97
ECG Gating in Positron Emission Computed Tomography	80
Emission Computed Tomography: A New Technique for the Quantitative Physiologic Study of Brain and Heart <u>In Vivo</u>	87
Investigation of 18-F-2-Deoxyglucose for the Measure of Myocardial Glucose Metabolism	87
Myocardial Imaging with Thallium-201: A Multicenter Study in Patients with Angina Pectoris or Acute Myocardial Infarction	93
N-13 Ammonia and Positron Emission Computed Axial Tomography for the Non-Invasive Assessment of Coronary Disease in Man	97
N-13 Ammonia for the Non-Invasive Measurement of Myocardial Blood Flow	96
Non-Invasive Assessment of Coronary Stenosis with Myocardial Perfusion Imaging During Pharmacologic Coronary Vasodilatation. V. Detection of 47% Diameter Coronary Stenosis with Intravenous Nitrogen-13 Ammonia and Emission-Computed Tomography in Intact Dogs	76
Physiologic Tomography: A New Means for the Non-Invasive Measurement of Myocardial Metabolism, Blood Flow and Function	94
Physiologic Tomography Measure of Cerebral and Myocardial Metabolic Rate for Glucose (MRglc): Models and Measurement Optimization	91
Physiologic Tomography of Myocardial Glucose Metabolism, Perfusion and Blood Pools with Multiple Gated Acquisition	91
Quantitation of Regional Myocardial Blood Flow by Positron Emission Computerized Transaxial Tomography	101

	PAGE NO.
SCHELBERT, HEINZ R. (continued)	
Quantitative Assessment of Regional Myocardial Perfusion by N-13 Ammonia (NH) and Positron Computed Tomography (PCT)	95
Regional Myocardial Perfusion Assessed by N-13 Labeled Ammonia and Positron Emission Computerized Axial Tomography	95
Single Pass Extraction of N-13 Ammonia by Myocardium and Its Relationship to Myocardial Blood Flow	81
Time-Course of "Redistribution" of Thallium-201 Administered During Transient Ischemia	96
SEVANIAN, ALEX	
Epoxides as Products of Lipid Autoxidation in Rat Lungs	36
Formation and Metabolism of Cholesterol Epoxide in Rat Lung	37
Lipid Peroxidation in Model and Natural Membranes	31
STEIN, ROBERT A.	
Autoxidation of Fatty Acid Monolayers Adsorbed on Silica Gel. III. Effects of Saturated Fatty Acids and Cholesterol	40
Autoxidation of Fatty Acid Monolayers Adsorbed on Silica Gel. IV. Effects of Antioxidants	41
Epoxides as Products of Lipid Autoxidation in Rat Lungs	36
Formation and Metabolism of Cholesterol Epoxide in Rat Lung	37
Lipid Peroxidation in Model and Natural Membranes	31
STROJAN, CARL L.	
Litter Fall from Shrubs in the Northern Mohave Desert	59
Trace Element Concentrations and Storages in Soils, Plants and Rodents in the Vicinity of the Mohave Generating Station in Southern Nevada	62
TAPLIN, GEORGE V.	
Imaging Sites of Airway Obstruction and Measuring Functional Response to Bronchodilator Therapy in Asthma	100
Improved Radioaerosol Administration System for Routine Inhalation Lung Imaging	100
Inhalation Lung Imaging with Radioactive Aerosols and Gases	98
Lung Clearance of Soluble Radioaerosols of Different Molecular Weights in Systemic Sclerosis	99

TAPLIN, GEORGE V. (continued)

Lung Perfusion-Inhalation Scintigraphy in Obstructive Airway Disease and Pulmonary Embolism	98
Sites of Airway Dilatation in Asthma Following Inhaled Versus Subcutaneous Terbutalin: Comparison of Physiologic Tests with Radionuclide Lung Images	100
Ventilation-Perfusion Lung Imaging in Diaphragmatic Paralysis	99

TURNER, FREDERICK B.

Ecological Effects of Precipitator Ash on Desert Plants and Animals	60
Litter Fall from Shrubs in the Northern Mohave Desert	59
Secondary Production by Desert Animals	60
The Status of the Flat-tailed Horned Lizard (<i>Phrynosoma mcallii</i>) at Nine Sites in Imperial and Riverside Counties, California	61
Trace Element Concentrations and Storages in Soils, Plants and Rodents in the Vicinity of the Mohave Generating Station in Southern Nevada	62

WALLACE, ARTHUR

Accumulation of Trace Elements by a Population of Corn Plants During a Simultaneous Acute Exposure	63
Ammonia vs. Nitrate in the Induction of Iron Deficiency and Growth of Bush Bean Plants	64
A Nutritional Disorder in Pistachio Near Athens, Greece	55
CaCO ₃ as the Sole Source of Calcium in the Growth of Tomato Plants in Solution Culture	64
Complete Neutralization of a Portion of Calcareous Soil as a Means of Preventing Iron Chlorosis	66
Effect of Acidification of a Calcareous Soil on Yield and Mineral Composition of Three Cultivars of Cotton Grown in a Glasshouse	59
Effect of Different Rootstocks on the Nutrient Element Composition of the Scion Leaves in Citrus	70
Effect of Irrigating Small Olive Trees Grown in a Glasshouse with Different Percentages of Seawater	66

WALLACE, ARTHUR (continued)

Effect of Soil Conditions and Botanical Characters on the Nutrient Level of the Leaves of Some Egyptian Flowers and Ornamental Plants	44
Effects of Arsenic Sprays on Different Citrus Fruit Juice Acidity	55
Excess Trace Metal Effects on Calcium Distribution in Plants	63
Excess Trace Metal Effects on Cotton: 4. Chromium and Lithium in Yolo Loam Soil	56
Excess Trace Metal Effects on Cotton: 5. Nickel and Cadmium in Solution Culture	57
Excess Trace Metal Effects on Cotton: 6. Nickel and Cadmium in Yolo Loam Soil	57
Further Development of the Use of Wastewater for Hydroponic Crop-Culture	45
Generalized Plant Nutritional Status of the Agricultural Lands of Egypt	64
Growth and Mineral Composition of Cotton Grown in Solution Culture with Different Nitrogen Sources	58
Influence of Phosphorus on Zinc, Iron, Manganese and Copper Uptake by Plants	66
Leaf Absorption of Metals Deposited as Dust on Leaves	68
Leaf Analysis of Citrus in Egypt	47
Leaf Analysis of Good, Intermediate and Stunted Sugar Cane in the Komombo Region of Egypt	65
Leaf Mineral Concentration of Some Citrus Scions on Different Rootstocks and Citrus Seedlings Grown in Greece	55
Mineral Composition of <u>Cuscuta nevadensis</u> Johnston (Dodder) in Relationship to Its Hosts	68
Mineral Element Concentration in Leaves of Some Citrus Varieties Grown in Greece	56
Mineral Element Concentration of Leaves of 23 Varieties of Olive	56
Nitrogen Cycle in the Northern Mohave Desert: Implications and Predictions	69
Nitrogen Fixation by Microfloral-Higher Plant Associations in Arid to Semiarid Environments	48

	PAGE NO.
WALLACE, ARTHUR (continued)	
Nutrient Concentrations in the Natural Vegetation of the Mojave Desert	48
Organic Acid Anions in Relationship to Cation and Nitrogen Nutrition in Tomato Plants	64
Phosphorus Levels and Soil pH on Phosphorus and Micro-nutrient Status of Cotton Grown in Soil in a Glasshouse	57
Plant Response to Nitrogen Fertilization in the Northern Mojave Desert and Its Relationship to Water Manipulation	59
Plant Uptake of Bicarbonate as Measured with the ^{11}C Isotope	67
Radionuclide Uptake by Plants	52
Role of Synthetic Chelating Agents in Trace Metal Uptake by Plants	70
Sodium Chloride on Growth, Mineral Composition and Gas Exchange Characteristics of Three Cultivars of Cotton Grown in Soil in a Glasshouse	58
Some Environmental Effects of the Aswan High Dam	65
Uptake of Mineral Forms of Nitrogen by Desert Plants	69
Variability in Mineral Composition of Orange Leaves of the Same Age and Collected from a Single Tree	68
Wastewater as a Hydroponic Growth Medium for Greenhouse Crop Culture	67
WARD, JOHN F.	
On the Mechanism of 5-Bromouracil Radiosensitization	40
Radiation Damage to DNA in Aqueous Solution: A Comparison of the Response of the Single-Stranded Form with That of the Double-Stranded Form	39
Radiation Damage to DNA in Aqueous Solution: Effects of Radiosensitizers	39
Serologic Assay of DNA Base Damage. I. 5-Hydroxymethyl-deoxyuridine, A Radiation Product of Thymidine	27
WOOD, ROBERT A.	
Plant Uptake of Bicarbonate as Measured with the ^{11}C Isotope	67

	PAGE NO.
WU, GUEY-SHUANG	
Autoxidation of Fatty Acid Monolayers Adsorbed on Silica Gel.	
III. Effects of Saturated Fatty Acids and Cholesterol	40
Autoxidation of Fatty Acid Monolayers Adsorbed on Silica Gel.	
IV. Effects of Antioxidants	41
Lipid Peroxidation in Model and Natural Membranes	31