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NUTRITION AND RADIATION INJURY: AN ANNOTATED BIBLIOGRAPHY

by

Doris Howes Calloway
Former Chief, Nutrition Branch

and

Lore Rose David
Assistant Librarian, Library Branch

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Introduction

The increased use of nuclear power in peaceful pursuits and as a potential instrument of war makes the problem of radiation injury an important consideration for all persons. Methods for mitigating the systemic effects of exposure to radiation have been sought since the early application of therapeutic doses in the medical field. Most of these early studies were clinical rather than laboratory and confounded by patient variables. With the advent of atomic warfare, efforts in this direction were intensified with major emphasis on the search for agents exerting protective effects against acutely lethal doses of radiations. Although these studies were essentially pharmacologic, careful measurements of metabolic patterns were included. This was followed by the consideration of the prophylactic role nutrition may have in radiation sickness.

This bibliography was undertaken at the request of the National Academy of Sciences, National Research Council Advisory Board on Quartermaster Research and Development, Committee on Nutrition. Its purpose is to bring together information on the relationships among diet, nutritional status, radiosensitivity, and radioprotection; and to suggest profitable areas for future research.

Having completed this exercise we can fully subscribe to the succinct evaluation of the state of the art as expressed by Nesterin and Yeremin (reference 24, below) "...a search for effective methods of preventing and treating radiation sickness -- specifically the development of a therapeutic and prophylactic nutrition method -- constitutes

an important problem in the struggle against organic disturbances caused by the action of ionizing radiation. At the same time the nutrition factor remains one of the least studied methods used in the treatment of the disease."

Explanatory Notes

Several excellent sources for review of the radiation syndrome have been listed in the first sections of this bibliography. A sampling of papers dealing with the various animal groups investigated have also been included. Discussions of metabolic behavior of each of these following exposure to irradiation are included in most of these. The literature in this field is enormous and we have elected to rely on these general references, excluding complete coverage from our compendium. A few entries have been annotated where the observations are not cited in common texts and are pertinent to specific topics covered later, or to nutrition studies in general. References to tissue levels and excretory patterns are presented briefly under each nutrient category. For those who wish to explore further, representative reviews on chemical protection, and some source material on the problems associated with the investigation of the product of fall-out have been given, although these topics are beyond the scope of the present bibliography.

Certain arbitrary decisions as to what constitutes a nutritional variable, had to be made. In the case of cystine, cysteine, and related thio-amines we have annotated those investigations in which the compounds were administered by mouth, where comparisons with other nutrients were made, or if the data were atypical. The many successful trials are shown by title only in the interest of conserving space. Most other "gray" areas were included.

Referenced materials not seen by the bibliographers are so noted, except for citations based entirely upon abstracting journals. Nuclear Science Abstracts, Chemical Abstracts and many others have been most useful. Credit has not been given to these sources in each particular instance, since most frequently not the complete abstract was used, but only an abbreviated portion pertinent to this bibliography. Foreign titles were not available in all cases, and all foreign titles are therefore cited in translation only.

The terminal date was December 1960.

Abbreviations

Aside from standard abbreviation for chemical substances, weights, and measures, etc., the following have been used in the abstracts:

hr	hour	n	neutron
irrad.	irradiation	r	roentgen unit
i.p.	intraperitoneal	vit.	vitamin
i.v.	intravenous	w.b.	whole body
min	minute		

These are used for all forms of the word: plural, singular, verb, and in combination with prefixes or suffices.

To avoid the excessively long designations of the various segments of the United States Atomic Energy Commission, and some other research units of the government, the following abbreviations which may not be recognized by those not familiar with the report literature, have been used.

Document Code Abbreviations

Unless otherwise specified the reports are obtainable from the Office of Technical Services, Dept. of Commerce, Washington 25, D.C., or for governmental agencies and contractors from the Atomic Energy Commission Technical Information Service Extension, Oak Ridge, Tenn.

AD	Documents, obtainable by governmental agencies and contractors from the Armed Services Technical Information Agency, Arlington 12, Va.
AECD	Atomic Energy Commission Declassified Reports.
AECU	Atomic Energy Commission Unclassified Reports.
ANL	Argonne National Laboratory Reports.
CH	Chicago University Metallurgical Laboratory Reports.
DA..MD..	Contract Reports to Surgeon General's Office, Washington 25, D.C.
IER	Naval Radiological Defense Laboratory (San Francisco, Calif.) Reports, (for AEC).
JPRS	Joint Publications Research Service, Washington, D.C., obtainable from OTS.
LAMS	Los Alamos Scientific Laboratory Reports.
MDDC	Manhattan District Declassified Codes; later continued as AEDC.
NEPA	Fairchild Engine and Airplane Corp. NEPA Division. Reports (Nuclear Energy for Propulsion of Aircraft).
NMRI	Naval Medical Research Institute, Bethesda, Md.
NRDL	Naval Radiological Defense Laboratory, San Francisco, Calif.
ORINS	Oak Ridge Institute of Nuclear Studies, Reports.
OTS	Office of Technical Services, Washington 25, D.C.
QM	Quartermaster.
TID	Technical Information Service Extension Reports.
UCLA	University of California at Los Angeles Reports.
UCRL	University of California Radiation Laboratory, Livermore, Reports.
UR	University of Rochester Reports.
USAEC-tr	Otherwise unnumbered translations by AEC Technical Information Service Extension.

USNRDL-TR Naval Radiological Defense Laboratory, San Francisco, Calif. Technical Reports.

WADC Hq., Wright Air Development Division, Air Research and Development Command, USAF, Wright-Patterson AFB, Ohio

Acknowledgement

An extensive bibliography gathered at the Massachusetts Institute of Technology, under U. S. Air Force Contract AF-19(604)-1109 in 1955, was made available to us through the courtesy of Dr. S. A. Goldblith. The Libraries at Oak Ridge and Argonne National Laboratories provided us with many government reports.

Several Institute staff members have contributed to this publication: Mr. Walter L. Necker, Chief of the Library Branch, guided the publication of the Library Bulletin; Dr. Nicholas Grecz translated numerous articles from the original Russion; Major A. H. Munson, (VC), USAF, assisted in selection and compilation of entries; and the herculean effort of typing fell to Mrs. Jacqueling Connolly, and of the typing of masters to Mrs. Mattie D. Perkins. Editorial supervision was by Mr. Benjamin S. Yamashita of the Technical Services Office.

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BRUCER, MARSHALL. The acute radiation syndrome; a medical report on the Y-12 accident, June 16, 1958. ORINS 25. 1959. 2.

Blood changes and changes in urinary excretion are tabulated. Absence of serine is noted. Beta-aminoisobutyric acid (BAIBA) has been found in urines from a group of human beings accidentally exposed to serious radiation. Levels of BAIBA excreted appear related to the estimated doses received.

CARSTEN, A. L. & J. R. M. INNES. Experimental myelomalacia in rats produced as a long-delayed sequel to X-irradiation. (Abstr.). Rad. Res. 12:426, 1960. 3.

Defect occurs after a latent period of a few to 12 months. Animals show loss of sphincter control, ataxia, paresis of the limbs and tail which progresses to complete flaccid paralysis. Latter cannot be differentiated from that seen in a form of spontaneous demyelinating disease of the spinal cord, chronic vit. E deficiency, or in certain cases of spinal tumors.

CASTANERA, T. J., D. C. JONES, & D. J. KIMELDORF. The pattern of dental defects observed in rats exposed to whole-body neutron or X-irradiation. (Abstr.). Rad. Res. 12:426, 1960. 4.

Structural defects in lower incisors began to appear approximately 35 days post-irrad. (neutrons: 232, 321, 362 rad; X-ray: 450, 710 r), and were visible for periods up to 5 weeks; upper incisors 15 days later. Incidence 93% at 450 r, 100% all other exposures. Intensity and number of lesions dose dependent and neutrons more damaging than X-ray of approximately equal lethality.

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Mice developed dental deformities after single dose 1250-1800 r of X-irrad. of the head. Mice affected severely were unable to feed adequately on food pellets and gradually starved to death unless provided with a soft diet. Administration of 9 mg. of 2-mercaptoethylguanidine·HBr (prepared from S, 2-aminoethylisothiuronium·Br·HBr) i.p. 10 min before irrad. afforded marked protection against these changes. Dental deformities were not observed in animals exposed to doses below 1000 r or in non-irrad. controls.

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II. DIGESTION AND ABSROPTION

A. PHYSIOLOGY. GENERAL

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Dogs were studied 132 hr after 500 r w.b. X-irrad. Uric acid and NPN levels in lymph rose 4 hr after exposure, then fell to below normal, whereas creatinine fell first then rose to normal. Sugar and chloride were unchanged.

CONARD, R. A. Effect of X-irradiation on intestinal motility of the rat. Am. J. Physiol. 165:375-85, 1951. 46.

Dose dependent events are described which are inhibited by drugs which inhibit acetylcholine and are augmented by acetylcholine augmentors. Site of action appears to be the intestine, on the vagus at the level of the enteric ganglia.

CONARD, R. A. Effect of X-irradiation on weight and contents of the rat stomach, small intestine, and cecum-colon. Proc. Soc. Exp. Biol. Med. 82:333-37, 1953. 47.

W.b. irrad. of 500 r produced 15.7, 34.4, and 23.6% losses in the weights of the stomach, small intestine, and cecum-colon, respectively of male rats in the 3- to 4-day post-irrad. period. Reduced contents of the small intestine and the cecum-colon indicated abnormal bacterial action.

CONARD, R. A. Some effects of ionizing radiation on the physiology of the gastrointestinal tract: A review. Radiation Res. 5:167-88, 1956. 48.

FENTON, P. F. & A. M. DICKSON. Changes in some gastrointestinal functions following X-irradiation. Am. J. Physiol. 177:528-30, 1954. 49.

Intestinal and pancreatic amylase activity were normal in irrad. (500 r, X) mice. Gastric emptying was reduced and the inhibitary effect of hypertonic solutions on gastric evacuation was abolished.

GOODMAN, R. D., A. E. LEWIS, E. A. SCHUCK. Effects of X-irradiation on gastrointestinal transit and absorption availability. Am. J. Physiol. 169:242-47, 1952. 50.

The quantitative changes in gastrointestinal propulsion in X-irrad. (450 r) rats are described. Following X-irrad. there is a decrease in gastric emptying rate. This occurs within 24 hr., reaches a maximum in 48 hr. and thereafter slowly tends to return to within normal limits. Transit time from the pylorus to the ileocecal junction was not affected by X-irrad. to a significant degree. Following X-irrad. the maximum limit of absorption availability from the small intestine is markedly diminished. The greatest change occurred between the 4th and 7th days after irrad. A return to within normal limits was not achieved even by the 21st post-irrad. day. The data suggest that a change in gastric transit is the chief determinant of small intestinal absorption availability following X-irrad.

IVY, A. C., J. E. McCARTHY, & B. H. ORNDOFF. Studies on the effect of roentgen rays on glandular activity. iv. Effect of exposure of abdominal and thoracic areas to roentgen rays on gastric secretion; note on roentgen cachexia. J. Am. Med. Assoc. 83:1977-83, 1924. 51.

Following abdominal irrad. in the dog, sufficient to cause first degree burns ($2\frac{1}{2}$ x HED*), there is a brief period of decreased gastric-juice secretion with anacidity and anorexia, followed by return to normal. One HED irrad. caused hypernormal secretion for 1-2 days, then hyponormal secretion and diarrhea, and normal secretion by 5 days. 0.75 HED irrad. caused anorexia, anacidity, and hyposecretion. Irradiation of thorax had no effect on gastric secretion.

*HED = Human Erythema Dose, appr. 120 min. exposure, 5 ma, 200 KV minutes, 50 cm focal distance, 11 x 21 cm portal, 0.75 mm copper, and 1 mm aluminum filter.

KMIETOWICZ, F. & J. TUMIDAJSKI. Activation of proenzymes with X-rays. Compt. Rend. Soc. Biol. Paris, 42:380-81, 1925. 52.

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NESTERIN, M. F. In: Abstracts of Reports: Scientific Conference on Problems of the Physiology and Pathology of Nutrition, Tartu, 1957. 53.

During the first few days after 600 r irrad. and again just before death, secretion of enterokinase, phosphatase, and saccharase in intestinal juice is reduced in dogs. (Not seen).

NESTERIN, M. F. The secretory function of the intestine in radiation sickness. Med. Radiol. 3: no. 5, 42-46, 1958. 54.

The activity of enterokinase in the secretory function of an isolated section of duodenum was studied.

NIKOL'SKII, V. V. & G. V. RUBTSOVA. Effect of X-ray irradiation on the formation of enzymes in the pancreas. Translated from Voprosy Med. Khim. 6:365-67, 1960. (OTS JPRS-7269). 55.

During the first month following irrad. in the region of the fistula formed after an operation for a pancreatic cyst, the trypsin activity in the secreted fluid decreased 17-fold; the amylase activity decreased 2-fold. A drastic decrease in lipase activity was observed during the subsequent periods. The fistula was closed within 5 months after irrad.

ORNDORFF, B. H., J. I. FARREL, & A. C. IVY. Studies on the effects of roentgen rays on glandular activity. v. The effect of roentgen rays on external pancreatic excretion. Am. J. Roentgenol. 16:349-54, 1926. 56.

Changes in pancreatic secretion and enzymatic activity are induced by irrad. and vary with dose.

PATETTA-QUEIROLO, M. A., M. L. RANDOLPH, & J. A. SPROUL, JR. Intestinal weight loss in mice irradiated by roentgen rays, gamma rays, and fast neutrons. Acta. Radiol. 49:393-400, 1958. 57.

Mice were exposed to graded doses of Co^{60} gamma rays, 250 kv roentgen rays, or 14 mev fast neutrons. The weight of the small intestine decreased during the first 48 hr after irrad. as a linear function of dose over the range 50 to 700 rads. No significant differences between radiations in the production of this effect were observed 1 day after irrad., but at 2 days the relative biologic effectiveness (RBE) increased with linear energy transfer being 1.0, 1.5, and 2.0 for gamma rays, roentgen rays, and neutrons, respectively. The RBE of neutrons for intestinal weight loss was appreciably higher than for 30-day lethality.

RAUCH, R. F. & K. W. STENTSTROM. Effects of X-ray radiation on pancreatic function in dogs. Gastroenterology 20:595-603, 1952. 58.

Irrad. of the dog (400 and 600 r) caused a brief reduction in pancreatic secretion, followed by increased secretion. Amylase activity dropped 28-88% and returned to normal in 4 days. Parallel changes in lipase and trypsin were seen but trypsin activity was recovered more slowly than that of amylase and lipase.

ROSS, M. H. & J. O. ELY. Neutron and roentgen-ray effects on protein content of rat intestine. Am. J. Roentgenol. Radium Therapy 62:718-22, 1949. 59.

Decreases in the tyrosine and tryptophan contents of intestinal crypts were noted following 600 r w.b. X-irrad. in rats and after 100 and 200 n neutrons irrad. but not after 56 n. Arginine contents decreased 24 hr. after 600 r or 200 n irrad.

SMIRNOV, K. V. Secretory function of the small intestine in dogs in acute radiation sickness. Med. Radiol. 3: no. 5, 46-51, 1958. 60.

The secretory function of the small intestine was studied in 25 dogs with isolated intestinal loop by Thiry's method. Intestinal juice was obtained by mechanical stimulation. The quantity of the juice recovered within 6 hr. was measured. The activity of enterokinase, acid phosphatase, peptidase, and lipase was investigated. All dogs were irrad. by X-rays in the dose of 400 r. The periods of increased fermentative activity of intestinal juice were observed, as well as the rise of the quantity of the juice. These periods were alternated with periods of normalization and depression. Excretion of intestinal ferments in the feces of dogs corresponded to the changes of activity of the ferments in the juice. Milk-egg and liver diets did not normalize the secretory processes of the small intestines in dogs.

SNELL, A. M. & J. L. BOLLMAN. Gastric secretion following irradiation of exposed stomach and upper abdominal viscera by roentgen rays. Am. J. Dig. Dis. 1:164-68, 1934. 61.

Irrad, of the upper abdomen in dogs produces a variable and temporary reduction in gastric acidity and a destruction of the gastric mucosa.

SZEGO, E. & J. ROTHER. Influence of X-rays upon gastric secretion. Zschr. Ges. Exp. Med. 24:270-88, 1921. 62.

Irrad. causes first an increase in gastric secretion followed by a prolonged depression.

USPENSKII, YU N. Effect of ionizing radiation on the activity of digestive organs in dogs. Fiziol. Zh. S.S.S.R. 43:328-35, 1957. 63.

The changes in activity of all digestive organs in dogs, exposed to 660 r localized abdominal irrad. are described. Salivary gland secretion decreased abruptly followed by 1½ to 2-fold increase with gradual decrease to initial rates after 2-3 weeks. Amylase was found in saliva; the content of ash in the solid fraction increased. Gastric secretion rose immediately after exposure, decreasing 2-3 days later. Secretion of intestinal glands rose to 1½ times the initial rate, then decreased considerably. Salivary and gastric juice proteins increased while serum protein decreased.

USPENSKII, YU N. Effect of ionizing radiation on the activity of intestinal glands. Fiziol. Zh. S.S.S.R. 44:225-30, 1958. 64.

The stimulated secretion of the intestinal glands of dogs exposed to a w.b. X-irrad. of 660 r was increased during the first few days following exposure. The amylolytic activity of the intestine was increased during this period. 2-3 weeks after irrad. the secretion decreased, reached a minimum and returned to normal after 4-8 weeks. Amylolytic activity followed the same pattern.

USPENSKII, YU N. The effect of ionizing irradiation on the activity of the organs of the digestive tract. Med. Radiol. 1: no. 1, 66-68, 1956. 65.

Dogs were exposed to 650 r abdominal irrad. Spontaneous acid secretion occurred in the stomach initially, followed by a phase of inhibition and a second phase of increased secretion of hyperacidity. Blood sugar was 98-105 mg % immediately after exposure, rose to 140 mg % and dropped again to 70-80 mg %. Serum protein, A/G ratio and blood hemoglobin were reduced.

USPENSKII, YU N. & A. V. AFANAS'EVA. Dynamics of composition of proteins of blood serum and digestive juice in experimental radiation sickness in dogs. Fiziol. Zh. S.S.S.R. 44:565-69, 1958. 66.

Seven dogs received 600-660 r X-irrad. for 30 min. in the stomach region. The protein in the saliva increased, reaching a maximum in 9-17 days. Stomach juice protein did not exhibit a definite pattern. A/G ratio was always increased. Intestinal juice contained 1.11-1.28% protein; fell to 0.46% 2 days after exposure with gradual increase to 2.2% on the 11th day; followed by another drop to 0.93% and increase to 1.05%. A/G ratio: first day, 3.92; then 1.51 followed by increase to 2.74-2.94.

WOODWARD, K. T. & S. M. ROTHERMEL. Observations on gastrointestinal function after X-ray and thermal column exposures. i. Effect on the progress of barium meal, body weight, and survival. Radiation Res. 5:441-49, 1956. 67.

Relatively low doses of acute w.b. irrad. (50 rep) induced gastric retention of barium in rats, the severity and duration of which increased with radiation dose. Body weight at 72 hr decreased linearly with dose after thermal column and 250-kvp X-ray exposure up to 1200 r. Subsequent to doses of 1200 to 900 r weight loss at 72 hr (median survival time 86 hr) was similar to, but did not exceed, that of non-irrad., starved, and thirsted controls. The relative biological effectiveness of thermal neutron irrad. as compared to that of 250-kvp X-irrad. was 1.1 when 1% starvation weight loss was used as the biological indicator of effect. Surgical removal of the pylorus had no effect on post-irrad. gastric retention. Gastroectomized, irrad. animals lost body weight comparable to unoperated irrad. animals. Diminished food intake and weight loss were unrelated to acute gastric retention and dilatation.

B. PROTEIN AND AMINO ACIDS

See also nos. 79, 197, 491, 524

BENNETT, L. R., S. M. CHASTAIN, A. B. DECKER, & J. F. MEAD. The effect of roentgen irradiation upon protein absorption in the mouse. Proc. Soc. Exp. Biol. Med. 77:715-18, 1951. UCLA-137, 1950. 68.

No defect in protein absorption was seen.

FEDOROV, I. V. The rate of absorption of glycine from the intestine of animals in acute radiation sickness. Med. Radiol. 4: no. 7, 87-88, 1959. 69.

It was found that the rate of absorption of digested protein products was not affected during the latent or acute periods of radiation sickness.

OKULOV, N. M. Effects of acute radiation sickness on the absorption of methionine from the gastrointestinal tract. Med. Radiol. 1: no. 5, 41-44, 1956. 70.

Methionine was introduced into stomach by rubber catheter (0.05 mg/kg body weight). Rate at which S^{35} appeared in peripheral blood was used as index of absorption. Rate of absorption from the gastrointestinal tract of X-irrad. rabbits was depressed during the first hours following exposure. Delayed absorption was seen for the duration of symptoms of radiation disease. Depth of depression varied directly with radiation dose.

SHATERNIKOV, V. A. Concerning the mechanisms of disturbance of intestinal absorption of glycocoll following X-ray irradiation. Med. Radiol. 3: no. 5, 37-42, 1958. 71.

Absorption of glycine from its hypertonic (M/2) and isotonic (M/3) solutions was examined in an isolated Thiry intestinal loop. Disturbance of the processes of glycine absorption in irrad. animals depended on the depression of the oxidative phosphorylation in the intestinal epithelial cells.

C. FAT

See also no. 232

CONIGLIO, J. G., W. J. DARBY, J. A. EFNER, J. FLEMIN & G. W. HUDSON. Effect of total body X-irrad. on fat balance and liver lipids in the rhesus monkey. Am. J. Physiol. 184:113-18, 1956, 72.

No defect in fat absorption was found in monkeys due to 325, 400, or 650 r X-irrad. Liver lipid concentration was unchanged but liver weight was increased.

CONIGLIO, J. G., W. J. DARBY, M. C. WILKERSON, R. STEWART, A. STOCKELL & G. W. HUDSON. Effect of X-irrad. on fat balance and on lipid and vit. A content of the liver. Am. J. Physiol. 172:86-92, 1953. 73.

No impairment of fat absorption nor significant change in the concentration of lipids or of vit. A in the liver attributable to 500 or 650 r w.b. X-irrad. was seen in rats fed a purified diet (25% casein, 20% shortening) during 4 weeks post-irrad. Importance of paired-feeding is stressed.

DODDS, E.C. & J. H. D. WEBSTER. Metabolic changes associated with X-ray and radium treatment. Lancet 258:533-37, 1924. 74.

There is an increase in fecal fat in humans treated with X-rays.

MARTIN, C. L. & F. T. ROGERS. Intestinal reaction to erythema dose. Am. J. Roentgenol. Radium Ther. 10:11-19, 1923. 75.

Absorption of cream is diminished as a consequence of irrad. in dogs.

MEAD, J. F., A. B. DECKER & L. R. BENNETT. The effect of X-irrad. upon fat absorption in the mouse. J. Nutrition 43:485-500, 1951. UCLA-90, 1950. 76.

Absorption of methyloleate was followed in normal and w.b. X-irrad. (600-700 r) mice. There was some retention of oil in the stomach and rapid passage past absorbing surfaces but fat absorption per se appeared normal. A post-irrad. increase in fecal fat occurred in animals on a fat-free as well as fat containing diet.

MOREHOUSE, M. G. & R. L. SEARCY. The effects of irradiation on the absorption and distribution of dioleylpalmitin-C^{14} in the rat. Radiation Res. 4:175-85, 1956. 77.

Rats exposed to 500, 1000, or 1500 r single w.b. doses or 500 r multiple doses every other week were given 0.46 g of dioleylpalmitin-C^{14} by stomach tube 3 or 6 hr previous to sacrifice. Increased stomach retention varied with X-ray dose and time of feeding after irrad. Slower absorption rate was indicated by decreased incorporation of C^{14} into intestinal wall lipids and increased amounts in intestinal lumen. In the liver increased amounts and rate of incorporation of C^{14}-palmitic acid into phospholipids may be due to their increased synthesis in irrad. animals.

MOTTRAM, J. C., W. CRAMER, & A. H. DREW. Vitamins, exposure to radium and intestinal fat absorption. Brit. Journ. Exp. Pathol. 3:179-81, 1922. 78.

Rats were fed a standard diet of starch, purified casein and salt mixture. If olive oil and vit. B were added the fat was absorbed by streams of fat entering cells. With 0.66 rads radiation no fat absorption at all took place, even in presence of vit. A and B. With 0.28 rads radiation, absorption by drops only, with or without vit. With 0.09 rads: olive oil with vit. B gave only drops; cod liver oil, drops and slight streams, if vit. B added.

SCHWARTZ, E. E. & B. SHAPIRO. Studies on chemical protection against radiation-induced intestinal injury. TID-5827, TID-6868, 1960. 79.

Mice were fasted 18 hr and exposed to w.b. X-irrad. in doses 400 to 1400 r 10 minutes after i.p. injection of a sham solution or 175 mg/kg/mercaptoethylguanidine (MEG) or 30 min after peroral administration of 400 mg/kg of MEG or sham solution. After 30 hr of feeding and a 24-hr fast, 0.15 or 0.25 cc of I^{131}-labelled oleic acid was force fed, followed by 0.05 cc of dextrose-amigen solution. Absorption was measured at intervals over 24 hr. Gastric retention was noted as a dose-dependent phenomenon; therefore, absorption was based upon amt. of labelled material reaching the intestine, i.e. corrected for amount remaining in stomach. Absorption was impaired by all radiation doses above 400 r; the defect was to a large degree prevented by MEG but MEG itself tended to reduce absorption. MEG prevented increased gastric retention as well. After feeding following by a 4 hr fast (53 hr post-irrad.) 0.15 cc of a 5% solution of I^{131}-labelled serum albumin was fed and absorption measured 1 hr later. No defect in absorption was seen.

D. CARBOHYDRATE

BARRON, E. S. G., W. WOLKOWITZ & J. A. MUNTZ. The effect of X-rays on the metabolism of the small intestine and its permeability to glucose. CH 3725 1946. MDDC-1241 1947. 80.

There was a steady diminution of glucose absorption by rat intestine following X-irrad. (50-500 r). Phosphorylation of fructose was also decreased.

BUCHWOLD, K. W. The influence of X-ray lesions of the intestinal mucosa on absorption of glucose and other sugars. J. Exp. Med. 53:827-33, 1931. 81.

Sublethal dose of X-rays over abdomen of rats and thorax for control. 20 and 40 hr after irrad. the rate of absorption of glucose, fructose, and mannose was markedly diminished. Definite histological changes in intestinal mucosa were observed. The relative rate of absorption of the 3 sugars remained nearly unchanged.

DETRICK, L. E., H. C. UPHAM, D. HIGHBY, V. DEBLEY & T. J. HALEY. Influence of X-ray irrad. on glucose transport in the rat intestine. Radiation Res. 2:483-89, 1955. UCLA-302 1954. 82.

Decreased glucose absorption in rats occurs in the immediate post-irrad. period (4 to 40 hr) and greater inhibition of glucose absorption from 3d through 6th day. Histological recovery of intestinal epithelium on 3d day is not reflected in normal functional capacity. Maximum hydration occurred on the 6th day.

DICKSON, H. M. Effect of X-irradiation on glucose absorption. Am. J. Physiol. 182:477-78, 1955. 83.

Glucose absorption decreased in mice 72 hr after 500 r w.b. X-irrad.

FARRAR, J. T., M. D. SMALL, D. BULLARD & F. J. INGELFINGER. Effect of total body irradiation on absorption of sugars from the small intestine. Am. J. Physiol. 186:549-553, 1956. 84.

Absorption of glucose, fructose, and xylose was decreased at 4 and 20 hr after 1410 r exposure in rats.

GOLUBENTSEV, D. A. Alterations in glucose absorption from the intestines during acute radiation sickness. Med. Radiol. 3: no 4, 86-87, 1958. 85.

The rate of glucose absorption from the intestines during radiation sickness was studied in mice 1, 4, 24, and 48 hr and 3 to 10 days after exposure to 750 r irrad.

GOLUBENTSEV, D. A. & N. A. SHEVYREVA. Changes of glucose absorption in combined radiation injuries. (General irradiation combined with burns.) Eksp. Khir. 5: no.3, 57-58, 1960. JPRS-5729 86.

Combined treatment was 700 r irrad. followed by boiling water burns over 14-19% of body surface in rats. No substantial change of Kori coefficient of glucose absorption was found for burns above, but the combination of irrad. and burns led to considerable reduction of glucose absorption.

LOURAU, M. & O. LARTIGUE. The intestinal absorption of glucose in irradiated guinea pigs. Arch. Sci. Physiol. 5:83-92, 1951. 87.

Glucose absorption was studied 11-14 days after a single w.b. X-irrad. of 500 r. There was no difference in absorption of a 1 gm dose 30 min after ingestion, but absorption was significantly diminished in the irrad. group at later time intervals (27% less at 90 min). The authors suggest that faulty absorption is related to hyperglycemia (due to impaired utilization) rather than to diminution of phosphorylation.

MOSS, W. T. The effect of irradiating the exteriorized small bowel on sugar absorption. Am. J. Roentgenol. Radium Ther. Nuc. Med. 78:850-54, 1957. 88.

Irrad. of the exteriorized small bowel prolongs gastric emptying. It also decreases the rate of glucose and arabinose absorption from the small bowel but absorption of the glucose is influenced more severely. This suggests that phosphorylation is disturbed as well as the process of diffusion. However the magnitude of the change in the absorption of both sugars suggests that a decrease in the rate of diffusion is the major factor.

PEREPELKIN, S. P. Abstracts of reports of the 8th all-union meeting of physiologists, biochemists, and pharmacologists. p.473-74, Moscow, 1955. 89.

Diminished glucose absorption was reported in the irrad. dog prepared with Thiry fistula. (Not seen.)

E. MINERALS

See also no. 45

GOODNER, C. J., T. E. MOORE, J. Z. BOWERS & W. D. ARMSTRONG. Effects of acute whole-body X-irradiation on the absorption and distribution of Na^{22} and H^3OH from the gastrointestinal tract of the fasted rat. Am. J. Physiol. 183:475-84, 1955. 90.

Rate of disappearance of a dose of Na^{22} from the intestinal tract was decreased at 24, 48, and 96 hr after irrad. (650 r), the limiting factor being the mucosa. Kinetics of absorption of water and Na were studied 48 hr after 2000 r X-irrad. Irrad. increased the rate of movement of these substances from the blood into the intestine and decreased the outward flow.

LENGEMANN, F. The effect of whole-body X-irradiation on the absorption of Ca^{45} and Sr^{85} from the intestinal tract of the rat. Radiation Res. 13:892-97, 1960. 91.

In the young rat, 200 r X-irrad. significantly increased the amount of Sr^{85} and Ca^{45} crossing the intestine; 1000 r and 400 r were needed in the mature rat to increase passage of Sr^{85} and Ca^{45}, respectively. Increased absorption was present as early as 2 hr and as late as 48 hr after irrad. Feeding vs. fasting was without effect.

MORCZEK, A. Investigations on iron absorption by the irradiated intestinal tract. Strahlentherapie, 111:593-98, 1960. 92.

Patients who had received high doses of X-ray therapy on chest or on abdomen were studied comparatively. Oral iron absorption tests were made and plasma clearance of radioactive iron was studied. Iron absorption was impaired in patients who had abdominal therapy but not in those with chest irrad.

MORCZEK, A. Iron absorption under the influence of radiation therapeutics. J. Radiol. Electrol. 41:381-83, 1960. 93.

Iron absorption tests were positive in 15 patients, previous to irrad. of the abdomen, but negative after the terminal radiation. Irrad. of the breast had no effect on iron absorption.

F. VITAMINS

BENNETT, L. R., V. C. BENNETT, A. SHAVER, & T. GRACHUS. Absorption and distribution of vitamin A in X-irradiated rats. Proc. Soc. Exp. Biol. Med. 74:439-43, 1950. 94.

Absorption of vit. A by X-irrad. (625 r) female rats was measured 6 and 10 hr after a test dose. In the 6-hr test absorption was slightly less in irrad. rats during 1st 24 hr after irrad. and was increased during the next 5 days. After a 10-hr test absorption was 6-8% less in irrad. than control. Liver vit. A was diminished in irrad. animals at both time intervals. Carcass levels were diminished at 6 hr and same as control at 10 hr. Adrenal content was decreased at 6 hr and elevated at 10 hr.

DETRICK, L. E., H. C. UPHAM, A. K. DUNLAP, & T. J. HALEY. Thiamine transport across the irradiated isolated rat intestine. UCLA-471, 1961. 95.

Isolated intestine of rats subjected to 525 r acute w.b. X-irrad. showed decreased thiamine absorption on the 3d post-irrad. day. Intestinal absorption of thiamine did not reach the control values even after 17 days.

STRASHININ, A. I. The effect of whole-body irradiation by X-ray and radioactive cobalt on the excretion of ascorbic acid in the urine of guinea pigs. Vestn. Roentgenol. Radiol. 31: no. 6, 3-8, 1956. 96.

Ability to absorb ascorbic acid decreases 5-7 days after irrad. (sublethal). Urinary excretion decreases within 2 days, then rises again (500-1000 r) or fluctuates widely (2000 r).

VASILEISKII, S. S. The state of the internal factor (Castle's) and vitamin B_{12} in acute radiation sickness. Med. Radiol. 3: no. 1, 29-34, 1958. 97.

Vit. B_{12} content in the blood serum of dogs after total irrad. by X-rays with a dose of 400 r is normal during acute radiation sickness, as well as in periods afterwards. Absorption of vit. B_{12} introduced per os, is also normal (Castle's intrinsic factor is preserved).

III. F E E D I N G, G E N E R A L

A. VOLUNTARY FOOD AND WATER INTAKE

Not exhaustive, merely representative selection of references. Also see Section I references.

CASTER, W. O. & W. D. ARMSTRONG. Pair feeding as a control procedure in metabolic studies of the X-irradiated rat. J. Nutrition. 59: 57-65, 1956. 98.

Assumptions implicit in the use of pair-feeding techniques have been discussed. This type of experimental design assumes that the metabolic effects of starvation are major factors in determining the over-all experimental result. In the example studied this was not true...the non-critical use of pair-feeding techniques may constitute a distinct hazard.

ELLINGER, F. Pharmacological studies on irradiated animals. iv. Water intake of guinea pigs as a parameter of oral drug administration in experimental radiation therapy. Naval Med. Res. Inst. Res. Rep. 13:787-94, 1955. 99.

It was shown that there is a difference between the water intake of non-irrad. and irrad. animals. This difference is chiefly accounted for by a reduced water intake of the animals succumbing to the irrad.; these animals stopped drinking prior to death. It was noted that the water intake during the time prior to irrad. death was not significantly changed irrespective of the mortality produced later on by various X-ray doses.

McDONALD, R. E., R. E. JENSEN, H. C. URRY, V. S. BOLIN & P. B. PRICE. A study of the irradiation syndrome. i. Water, electrolyte and nitrogen balances. Am. J. Roentgenol. Radium Ther. Nuc. Med. 74:701-10, 1955. AECU-2882, 1954. 100.

Main abnormalities observed were: reduced total body water without significant dehydration; decreased water intake with nearly normal water losses; negative Na and K balances throughout the syndrome; inconsistently negative Cl balance before the onset of anorexia and consistently negative Cl balance after anorexia; increased K/Na balance ratio which, after anorexia, approached the K/Na ratio of muscle; no evidence from external balance studies of acid base disturbance or of gross depletion or internal shift of K, Na, or Cl. Prior to anorexia digestion, absorption, and metabolism of Na proceed normally. Most of the observed effects need not be regarded as primary radiation effects. Weight loss was more pronounced in animals on dry pellet diet than in those on palatable meat-rich diet, due to delayed onset of anorexia in the latter group.

NEWSOM, B. D. & D. J. KIMELDORF. Role of food consumption in the mortality response of irradiated rats subjected to prolonged cold exposure. Am. J. Physiol. 195:271-75, 1958. 101.

Mortality of rats subsequent to 500 or 600 r X-irrad. is greater at 6°C. than at 23°C. due to inadequate food intake.

NIMS, L. F. & E. SUTTON. Adrenal cholesterol, liver glycogen, and water consumption of fasting and X-irradiated rats. Am. J. Physiol. 177:51-54, 1954. 102.

Following X-irrad. (500 r) there is a rapid increase in water intake and decrease in adrenal cholesterol. These responses are abolished by hypophysectomy. Liver glycogen falls due to decreased food intake but irrad. reduces the fall from that seen in fasting alone.

NIMS, L. F. & E. SUTTON. Weight changes and water consumption of rats exposed to whole-body X-irradiation. Am. J. Physiol. 171: 17-21, 1952. BNL-1190. 103.

SMITH, D. E. & E. B. TYREE. Influence of X-irradiation upon body weight and food consumption of the rat. Am. J. Physiol. 177:251-60, 1954. 104.

Anorexia was noted following all exposures (25 r and above) but the pattern varied with total dose.

SMITH D. E. & E. B. TYREE. Influence of X-irradiation upon water consumption by the rat. Am. J. Physiol. 184:127-33, 1956. 105.

Polydipsia occurred in rats on the 1st and 2d days after irrad. of 25 r or above and again at the 5th and 6th days at 50 r or above. The response was highly variable between individuals and was abolished by adrenalectomy.

WEINER, N., L. J. MILCH, & G. E. SHULTS. The effect of reduced food intake on the hyperlipoproteinemia of local radiation injury. School of Aviation Medicine, Randolph AFB, Texas. AF-SAM-56-18, 1956. 106.

The possible effect of voluntary food reduction on the hyperlipidemia and weight loss produced in rabbits after acute local radiation injury was investigated. Pair-fed controls did not develop significantly elevated plasma lipid and lipoprotein levels and did not lose weight, as did their injured mates.

B. FASTING AND IMPOSED FOOD RESTRICTION

CARROLL, H. W. & R. W. BRAUER. Hypocaloric feeding and radiation tolerance. Res. and Develop. Technical Rpt. NRDL-TR-482. Naval Radiological Defense Laboratory, San Francisco, Calif., 1960. 107.

Radiation sensitivity and dose mortality curves of hypocalorically reared and freely fed rats were compared. Hypocalorically reared rats showed significantly reduced radiation resistance; they did not display recognizable body weight loss nor anorexic responses to radiation exposure as shown by rats fed ad libitum. Pattern of mortality was not different in hypocalorically fed rats and controls.

CARROLL, H. W. & R. W. BRAUER. Hypocalorically fed retarded rats as test subjects in the study of delayed effects of X-irradiation. (Abstr.) Fed. Proc. 16:288, 1957. 108.

Hypocalorically-maintained rats were found to be considerably more radiosensitive than their normally fed controls. Other differences noted were the absence in the hypocaloric group of the anorexia and weight loss which is observed in normally fed controls. A 2nd series of these hypocalorically fed "age retarded rats" were then irrad. with 800 r (200 r/wk) 250 kvp X-irrad. which in test runs had failed to kill any of the restricted rats. Restriction of food intake was continued for 45 days following exposure. At this time the irrad. rats and their non-irrad. controls were realimented. Results of body gain in these animals indicate that the previously irrad. rat fails to respond to the realimentation schedule in the same fashion as non-irrad. controls.

SMITH, W.W. Survival after radiation exposure: Influence of a disturbed environment. Nucleonics 10:80-83, 1952. 109.

Moderate exercise and no food or a poor diet for a short time could be tolerated by rats and mice given 400-700 r X-irrad. Extreme exercise and cold were not tolerated well.

SMITH, W. W., I. B. ACKERMANN, & F. SMITH. Body weight, fasting, and forced feeding after whole body X-irradiation. Am. J. Physiol. 168:382-90, 1952. 110.

The weight pattern in rats, mice, and guinea pigs following w.b. X-irrad. was a stronger characteristic of species than of dose or lethality. Fasting did not significantly alter mortality. Forced feeding a partially predigested diet by stomach tube was detrimental to rats when the feedings were given during the first 3 days following irrad., but was not damaging when given after the 4th day. Stasis of the alimentary contents of the rat was observed after radiation, principally in the stomach.

TAKETA, S. T. & M. N. SWIFT. Early (3-5 day) mortality in rats given supralethal whole-body X-irradiation and the protective effect of fasting. (Abstr.) Fed. Proc. 15:184, 1956. 111.

In rats given 825 r of w.b. X-irrad., 24 hr pre-exposure fasting affords significant protection against 3- to 5-day intestinal deaths.

TAKETA, S. T. & M. N. SWIFT. Modification of protection afforded by pre-exposure fasting against intestinal radiation mortality. (Abstr.) Fed. Proc. 16:127, 1957. 112.

Protective effect of fasting has been found to be nullified by feeding fasted animals ad lib. for a 15-min period 1½ hr before, but not immediately before, X-irrad. (900 r 250 kvp). Five-day mortalities were 70 and 36% respectively. It was found that 24-hr fasting caused the mean gut wet weight to drop about 18% below that of fed controls (from 5.6-4.6 g). Feeding of fasted rats elicited rapid recovery of gut weights which were 5.0 and 5.4 g for animals fed immediately before and 1½ hr earlier, respectively. These results suggest that the protective effect of pre-exposure fasting may be related to its depressing influence upon intestinal function.

C. FORCED FEEDING, PARENTERAL FEEDING

See also nos. 44, 110,

ANON. Forced feeding following irradiation. Nutrition Rev. 14: 313-15, 1956. 113.

A review of the work of D. E. Smith and E. B. Tyree.

AKIN, P. V., J. G. CONIGLIO, & G. W. HUDSON. The effect of orally administered fat emulsion on survival of the irradiated rat. Radiation Res. 6: 543-47, 1957. 114.

The effect of forced feeding a 30% cottonseed oil emulsion to rats irrad. with 750 r or 1000 r Co^{60} or with 800 r X-irrad. was studied. No definite effects due to the emulsion were noted at the lower level of Co^{60} irrad. With 1000 r Co^{60} and with 800 r X-irrad. the rats fed fat emulsion had lower food consumption, more severe diarrhea, greater stomach distension, and shorter survival times than their irrad. controls force-fed water.

BELOUSOV, A. P. Some means of eliminating erythrocyte hemolysis induced by ionizing radiation. Med. Radiol. 2: no. 2, 46-54, 1957. 115.

Deals with parenteral administration of solutions of casein, parathyrin, sucrose, and colloidal-salt to rabbits.

JENNINGS, F. L. Comparison of parenteral and oral protein feeding on radiation susceptibility in protein-depleted rat. Proc. Soc. Exp. Biol. Med. 80:10-13, 1952. 116.

Parenteral feeding of protein hydrolysate following irrad. has no advantage over oral administration in the protein-depleted rat as measured by radiation susceptibility. It may be advantageous in preventing early post-irrad. weight loss.

KOSHELEV, N. F. Feeding by mouth in radiation sickness. Voprosy Pitania 18: no. 3, 36-40, 1959. (OTS JPRS-L-893-N) 117.

White mice and rats were subjected to 500-600 r w.b. X-irrad. and beginning 1 day after exposure were given: acid or enzyme-hydrolyzate blood protein, aminopeptide, "L-103, curative serum of N. G. BELENKY", 5% glucose or 0.85% NaCl. Weight and survival were poorer than in control groups.

SMITH, D. E. & E. B. TYREE. Attempts to provide the rat with nutrition during post-irradiation anorexia. Radiation Res. 4:435-48, 1956. Fed. Proc. 11:149, 1952. ANL-4713, 1951. 118.

In rats exposed to 800 r w.b. X-irrad. mortality, caloric intake and body weight responses were similar whether ground Derwood checkers or a vit.-fortified fluid milk diet (1 Cal. per ml.) was given. Force-feeding by stomach tube of a semi-fluid diet (10 ml. twice daily of a diet containing celluflour, salts, cod liver oil, wheat germ oil, corn oil, brewer's yeast, and whole milk powder) or of a fluid diet (9 ml. twice daily or 5 ml. 4 times a day of 10% protein hydrolysate (Amigen) plus 25% dextrose solution) allowed weight gain but was detrimental to survival. Essentially comparable results were noted when the latter solution was administered subcutaneously. Pre-treatmet with cysteine (i.v.) ameliorated the anorectic response.

D. OBESITY

SMITH, W. W., W. H. CHAPMAN & I. M. ALDERMAN. Whole-body X-irradiation of obese mice. Am. J. Physiol. 169: 511-14, 1952. 119.

Mortality is similar in normal and obese mice (genetic and gold thioglucose treated) given 500-2000 r X-irrad., suggesting that inanition is secondary to processes which terminate in death rather than a cause of death.

SPIERS, F. W. Effective atomic number and energy absorption in tissues. Brit. J. Radiol 19:52-3, 1946. 120.

Differences in the amount and distribution of body fat can account for small differences in individual sensitivity because of the low effective atomic number of fat.

E. MISCELLANEOUS

DAVIS, R. T., C. B. ELAM, & A. A. McDOWELL. Latent effects of chronic whole-body irradiation of monkeys with mixed source radiation. Rpt. 57-59 Air University, School of Aviation Med. Randolph AFB, Texas, Feb. 1958. 121.

Changes in specific food preference and behavior were noted.

GARCIA, J. & D. J. KIMELDORF. Some factors which influence radiation-conditioned behavior of rats. Radiation Res. 12:719-27, 1960. 122.

Localized X-ray exposure of the head, thorax, abdomen, or pelvis served as a motivating stimulus to condition a saccharin aversion in rats. It is suggested that sensations triggered by gastric dysfunction may represent the stimuli through which radiation acts to condition behavior in animals.

KUZNETSOVA, L. V. The senses of taste and smell in persons working on betatrons. Med. Radiol. 5: no 4, 82-84, 1960. 123.

100 persons, 29-40 years old, worked on betatrons for the periods from 4-10 years in conditions of combined effect of penetrating radiation. It was shown that the sense of taste decreases to all stimuli, mainly to the bitter stimulus. The olfactory thresholds were increased to all substances used as stimuli. The absence of any complaints on impairment of the sense of smell points to the gradually developing hyposmia. Simultaneous diminution of the sharpness of taste and smell is noted in 43% of the cases.

IV. PROTEIN AND AMINO ACIDS

For nucleic acids, see entries under XXVI. D. YEAST

A. CLINICAL STUDIES

See also no. 356.

HEALY, J. B. A trial of cystamine in radiation sickness. Brit. J. Radiol. 33:512-14, 1960. 124.

Cystamine given perorally 100-400 mg/day after irrad. had no definite effect in prevention of radiation sickness in 112 patients.

HERVE, A. & Z. M. BACQ. Chemical protection against X-rays; therapeutic tests. J. Radiol. Electrol. 33:651-55, 1952. 125.

A brief report is given of the authors' research on chemical protection against ionizing radiation. The therapeutic effects of amine derivatives and particularly of B-mercaptoethylamine are discussed. The results obtained with B-mercaptoethylamine injections in 30 cases of radiation sickness are tabulated.

B. LABORATORY STUDIES

1. DIETARY PROTEIN

ANON. Dietary factors and radiation damage. Nutrition Rev. 13:17-18, 1955. 126.

A resume of work on dietary composition (Cornatzer et al.) and B. vit.

BRADNER, W. T. & M. H. HATCH. Effect of dietary protein on mortality of X-irradiated mice. (Abstr.) Fed. Proc. 17:352, 1958. 127.

The 30-day mortalities for BUB strain mice maintained before and after 600 r X-irrad. on 54, 18, or 6% casein diets (varied against corn starch with fat, salts, and vit. constant) were 33, 57, and 88%, respectively. With 18% casein considered as "normal" protein, mortality was significantly decreased among mice fed the high protein diet and increased among mice fed the low protein diet. It is suggested that the protective effect may be due in part to enhanced ability of the mice fed 54% casein to cope with bacterial invasion.

CORNATZER, W. E., G. T. HARRELL, D. CAYER, & C. ARTOM. Subacute toxicity of radioactive phosphorus as related to the composition of the diet. Proc. Soc. Exp. Biol. Med. 73:492-95, 1950. 128

In mice on a 10% casein and 32% fat diet, the LD_{50} dose at the 21st day lies between 4 and 6 micro curies/g of body weight. Survival is highest with diet low in fat (5%) and in protein (10%) and is significantly decreased when fat (32%) or protein (25%) level or both are increased in diet. Enrichment of diets with inorganic phosphate (from 1.3% as H_3PO_4 to 2.9%) seems to afford moderate but significant degree of protection. No difference was seen between groups on either choline deficient or choline supplemented (0.5%) diet, whether or not poisoned with CCl_4.

ELSON, L. A. & L. F. LAMERTON. The influence of protein content of diet on the response of Walker rat carcinoma 256 to X-radiation. Brit. J. Cancer 3:414-26, 1949. 129.

Diets containing 20% and 5% protein were used. For w.b. irrad. (100 r daily for 8 days commencing 24 hr after tumor implantation) or for localized irrad. of the established tumor (4000 r total dose applied in daily doses of 250 r, commencing 6 days after tumor implantation) inhibition of tumor growth was greatest in those animals maintained on the low protein diet, but no complete regression of tumor was obtained. With localized irrad. of the tumor, when the total dose of 400 r was applied in large daily doses, complete regression of some tumors was obtained, most favorable results by application of initial dose of 1000 r with extended time intervals between successive smaller doses. Complete regression was then obtained in 90% of animals maintained on high protein diet, but in only 15% maintained on low protein. It is suggested that 2 effects are concerned in the response of tumors to irrad: 1. initial inhibition of tumor growth -- favored by low protein diet; 2. elimination of inhibited tumor and cure of animal -- favored by high protein diet.

ERSHOFF, B. H., A. F. WELLS, S. BERNICK, H. SOBEL, & T. N. GRAHAM. Chronic effects of low-level radiation upon protein and amino acid requirements. WADC Tech. Rpt. 59-609, 1959. 130.

Weanling rats were fed purified diets containing 10, 15, 25, or 45% protein (cystine supplemented casein) and continuously exposed to 0.3, 3, 30 or 300 r per week up to 20 weeks. Radiation effects were neither diminished or accentuated by variation in protein level. Other proteins and mixture of amino acids gave similar results. An oral dose of AET did not protect against a single acute dose of X-irrad. or 300 r exposure per wk for 8 wks. Behavioral changes were studied and radiation effects noted.

JENNINGS, F. L. Effect of protein depletion upon susceptibility of rats to total body irradiation. Proc. Soc. Exp. Biol. Med. 72:487-91, 1949. 131.

Protein-depleted rats (10 wks. to 25% weight loss on 1.9% protein diet), weight controls and age controls were subjected to 300-800 r doses of w.b. X-irrad. The same diets were fed after irrad. for 30 days. Protein depletion materially increased susceptibility to radiation injury. Weight and age had little influence.

KRISE, G. M. & S. O. BROWN. Effects of chronic gamma irradiation on the weight increment of albino rats deficient in protein in the influence of dietary deficiencies on the survival of albino rats and mice subjected to continuous low intensity radiation. DA-007-49-MD-957, 1960. 132.

Rats (50 g. 10 ea. male and female per group) were fed, during continuous Co^{60} irrad. at 2, 5, and 10 r per day or non-irrad., the following diets: 7 and 10% protein purified casein diets and Purina chow. Growth of males fed 7% protein was significantly depressed at the 10 r level after 20 weeks and to a lesser degree in females. The same trend was seen at 2 and 5 r in males on the 7% protein diet but did not reach significance. Smaller differences were seen in other diet groups. By 20 wks no neoplasms were seen in the low protein group, but 14 were recorded for the other diets, frequency increasing with radiation dose. This study is continuing.

MACK, P. B., G. P. VOSE, & R. E. PYKE. Skeletal status of the albino rat at varied protein levels in a constant radiation field. A study of changes in fracture healing in the albino rat and mouse subjected to radiation and dietary deficiencies. DA-47-007-MD-956. 35-54, 1959. 133.

Rats fed isocaloric diets containing 7, 10, 14, and 25% of protein (casein) were exposed to continuous gamma-radiation of 0, 2, 5, 10, and 20 r per day. Significantly lower body and skeletal weight gain were noted in groups on 7% protein diet given 0 or 20 r irrad. Bone density of groups given 7, 10, or 14% protein and 20 r irrad. was lower than comparable non-irrad. groups. Animals on low-protein diets tended to increase in percent of fat in the femur when exposed to radiation. (Earlier report Mar 1959 presents 10-week-data.)

NOONAN, T. R. Effect of diet on radiation. AEC UR-174, 1951. 134.

Survival of rats following 625 r w.b. X-irrad. is not significantly altered by the post-irrad. feeding of 25% casein-32% fat diet or 10% casein-5% fat diet as compared with fox chow.

NOONAN, T. R. & J. N. STANNARD. Influence of diet on survival of rats following whole body X-irradiation or polonium injection. UR-320, 1954. 135.

The 30-day mortality of rats following either 625 r of w.b. X-irrad. or the i.v. injection of 38 microcuries of polonium/kg body weight is not significantly changed by feeding synthetic diets with either 25% casein and 32% fat or 10% casein and 5% fat as compared to a standard fox chow diet.

SCHLESINGER, M. J., JR. The effect of a protein-free diet on recovery from X-irradiation injury in the rat. UR-279, 1953. 136.

The effect of a protein-free diet on recovery from X-irrad. has been investigated. Young adult rats exposed to 400 and 250 r X-irrad. one wk. apart and placed on a protein-free diet immediately after the first irrad. were studied. Response of the animals to the second dose was the criterion used to measure recovery. Results indicate that the protein-deficient diet leads to an increased number of mortalities in the irrad. animals compared to the mortality figures for groups of animals on an 18% casein diet treated in a similar manner. This increase is noted when the mortalities caused by the deficient diet alone and the deficient diet plus single irrad. doses are taken into consideration.

SMITH, W. W., I. B. ACKERMANN, & I. M. ALDERMAN. Effects of dietary protein and methionine on the X-irradiated rat. Am. J. Physiol. 169:491-98, 1952. 137.

Rats maintained before and after irrad. on diets containing 6% casein showed a slightly higher incidence of death after irrad. with 550 r than did rats on 18 and 35% casein diets. Reduction of the casein content of the diet after irrad. did not significantly alter 40-day mortality. When casein was increased to 60% the observed mortality was somewhat reduced, but the difference was not statistically significant. Addition of methionine and cystine to the low casein diets did not influence the incidence of death. The effect of irrad. on depression and recovery of leucocyte and erythrocyte production was not greatly influenced by diet, but a slight delay in reduction of circulating reticulocytes was observed in the 35% casein group. The average rate of oxygen consumption by nembutalized rats on a 6% casein diet was 12% below, and on a 60% casein diet 18% above the value for rats on the 18% casein diet.

WHITE, J., B. E. BURR, H. T. COOL, P. W. DAVID, & M. S. ALLY. Level of protein intake and nitrogen excretion in rats following total body X-irradiation. J. Natl. Cancer Inst. 15:1145-54, 1955. 138.

Rats fed a low protein (6% casein) diet show a marked increase in nitrogen excretion while those ingesting a 15 or 20% casein diet show a much lower increase in nitrogen excretion when given 450 to 500 r w.b. X-irrad. These increases in nitrogen excretion are to a great extent due to increased urea excretions and suggest increased protein catabolism. Shielding the spleen in the 6% protein group during X-irrad. results in partial protection against increased nitrogen excretion following radiation exposure.

WHITE, JULIUS, C. C. CONGDON, P. W. DAVID, & M. S. ALLY. Cirrhosis of the liver in rats following total-body X-irradiation. J. Natl. Cancer Inst. 15:1155-63, 1955. 139.

Liver cirrhosis developed in 53% of irrad. rats (450-500 r) kept on a 6% casein diet. Disease was not observed in 400 days when the diet contained 15 or 20% casein.

2. AMINO ACIDS AND AMINES

a. Peroral Administration

See also nos. 137.

BACQ, Z. M. Cystamine, given by mouth, as a prophylactic against radiation sickness. Bull. Acad. R. Med. S.6, 18:426-36. 140.

Maximal protection is provided to mice, if cystamine (dichlorhydrate, 4 mg/10g) is given 30 min before irrad. It is helpful beginning with 15 min post-irrad. and lasts for 3 to 4 hr.

BACQ, Z. M. & A. HERVE. New observations on the radioprotective action of ingested cystinamine. Compt. Rend. Soc. Biol., Paris 149:1509-12, 1955. 141.

Ingestion of 450 mg/kg or more of cystinamine (as HCl salt) 30 min before exposure protected rats from a lethal dose of X-rays. Similar but somewhat irregular results were obtained with mice.

BRAUN, WALTER, et al. Comparison of degree and time dependence of some sulfhydryl compounds in radiation protection. Strahlentherapie, 108:262-68, 1959. 142.

Of the substances tested, Beta-aminoethylisothiouronium chloride was superior to other compounds in oral administration.

HOLSTI, L. R. The mitotic and radioprotective effect of cysteine and lysine in rat. Acta Radiol. Suppl. 197, 99p., 1960. 143.

The amino acids cysteine and lysine were given in water solution by stomach tube. A single dose of cysteine 1250 mg/kg had a good protective effect whereas a single dose of lysine (1500 mg/kg) had no effect against X-irrad. (700 r) induced lethality. 3 successive doses of lysine (each 750 mg/kg) at intervals of 55 min lead to a marked protective effect; 68% of rats living 180 days. Similar repeated doses of cysteine had no effect beyond that of a single dose; 80% surviving for 240 days. Neither gave a statistically significant result with one wk treatment. Recovery of the initial mitotic depression in epidermis, stomach, and duodenum was more rapid in the amino acid treated groups, irrespective of whether the dosage protected against lethality. Neither lysine nor cysteine protect against carcinogenic effects of radiation. Initial weight loss was the same in amino acid-treated and control groups.

LANGENDORFF, H. & R. KOCH. B-aminoethylisothiouronium as an oral radioprotective agent. Naturwissenschaften 43:524-25, 1956. 144.

Rats were given the compound (as Br HBr salt) before 500 r w.b. X-irrad. either (a) 30 mg i.p. 10 min before with 66% survival or (b) 80 mg by stomach tube 30 min before with 54% survival. Control animals showed 28% survival.

MEWISSEN, D. J. Action of cystamine per os on the survival of mice irradiated by Co^{60}. Acta Radiol. Stockholm 48:141-50, 1957. 145.

Mice were assigned to groups receiving 4 different total doses of radiation according to a graded sequence, in 2 fractions at 5 day interval. In the group treated with cystamine per os the 30 day LD_{50} value increased from 416 r to 597 r. The degree of protection afforded was significant.

MEWISSEN, D. J. & M. BRUCER. Late effects of Gamma-radiation on mice protected with cysteamine or cystamine. Nature, 179:201-02, 1957. 146.

Mice received different total radiation doses in 2 exposures 5 days apart. Before each exposure mice of the protected group were given an i p. injection of cysteamine (3mg/10g) or a gastric intubation of cystamine (4mg/10g). In the group with 301 r total dose, the number of tumors was 4%, which approached the level expected in the controls. At other dose levels, incidence of tumors in protected mice was significantly higher than in unprotected mice.

NEWSOME, J. R. Whole-body radiation protection using enteric coated AET-PAPP combination in the dog. (Abstr.) Physiologist, 2: no.3, 89-90, 1959. 147.

A study was made on the protective ability of AET-PAPP combinations in enteric coated capsules against a lethal dose of whole-body X-irrad. in dogs. Doses of 100, 125, and 150 mg/kg AET (S-Beta-aminoethylisothiuronium), each combined with a 3.5 mg/kg PAPP (R-aminopropiophenone) were given orally to the animals. Each was subjected to a lethal dose of X-irrad. of 550 r. Even a dose of 100 mg/kg AET plus 3.5 mg/kg PAPP afforded partial protection, as the dogs given this dose survived about 23 days. At the time of death, the animals were anemic but leucocytes and reticulocytes were increasing in their peripheral blood. The AET in the enteric coated capsules was found to be relatively non-toxic.

PATT, H. M., D. E. SMITH, E. B. TYREE & R. L. STRAUBE. Further studies on modification of sensitivity to X-rays by cysteine. Proc. Soc. Exp. Biol. Med. 73:18-21, 1950 AECU-599, UAC-184. 148.

Cysteine improves survival signficantly if given i.v. or orally (1900 mg/kg) 30 to 60 min prior to irrad. with 800 r. Cystine, methionine, ascorbic acid and sodium sulfide do not alter sensitivity. Glutathione treatment is effective i.v. (625-1250 mg/kg) but not perorally (2000 mg/kg).

PRESTON, R. L. & A. HELLMAN. Influence of dietary cysteine upon the effects of continuous low-level irradiation. WADC TN 59-190, 1959. 149.

Continuous gamma-radiation (38.6 and 76.8 r/wk. given in 8- and 16-hr periods/day, respectively) was administered for 6 wks. to 9 growing rats/radiation level. These were compared to 9 controls. Within these 3 groups, 3 levels of cysteine (0%, 0.4%, and 1.6% of total diet) were individually fed in a factorial experiment to determine if this compound in the daily diet would alleviate the effects of continuous irrad. Adverse effects on a number of physiological variables caused by the irrad. were not alleviated by the administration of this compound. In fact, certain criteria were affected to a greater degree when the animals were fed the high level of cysteine (reduced body growth, feed consumption and efficiency, and thymus and spleen weights).

PRESTON, R. L., A. F. WELL, & B. H. ERSHOFF. Comparative effects of intra-peritoneal and oral administration of AET on survival of X-irradiated rats. Radiation Res. 11:255-59, 1959. 150.

Administration of 300 mg/kg i.p. of AET to rats shortly before exposure to 900 r X-irrad. resulted in a highly significant increase in length of survival. When administered at a level of 400 mg/kg AET decreased survival as compared to untreated controls. Oral administration by stomach tube at levels of 400 or 800 mg/kg AET shortly before irrad. or mixed in the diet and fed at graded levels (1,2,5,5, or 10 gm/kg) prior to or after irrad. was without effect.

b. Parenteral Administration

See also nos. 36, 79, 116, 117, 118, 137, 249, 253, 343, 367, 371, 378,386, 398, 414, 415, 417, 421, 462, 483, 508.

ALEXANDER, P., Z. M. BACQ, S. F. COUSENS, M. FOX, A.HERVE, & J. LAZAR. Mode of action of some substances which protect against the lethal effect of X-rays. Radiation Res. 2:392-415, 1955. 151.

The radioprotective activity of over 100 compounds was studied, using mortality of mice (700 r Cs LD 100) and in vitro degradation of a polymer as criteria. No description of the diet is given. Compounds were given i.p. administration (4×10^{-5} moles) 5 min before exposure.

Effective at least 70% survival	Mod. Effective at least 40% survival	Ineffective less than 40% survival
Histamine	Methylamine	Glycine
Tyramine	DOPA	Lysine
B-Phenylethylamine	Na salicylate	Arginine
Hydroxytyramine	Caprylic acid	Aspartic acid
m-tyramine	Formic acid	Glutamic acid
Tryptamine	Hippuric acid	Cystine
Fructose	Cysteine	Methionine
Serotonin	Homocysteine	Histidine
Diethyldithiocarbamate	Glutathione	Phenylalanine
Cysteamine		Tyrosine
Cystamine		Tryptophane
		Choline
		Glucosamine
		PABA
		Glycerol
		Na lactate
		Glucose
		Acetic acid
		Pyruvic acid
		Succinic acid
		Benzoic acid
		Indoleacetic acid
		Acetone
		Nicotinic acid (Na salt)
		KI

ARBUZOV, S. YA, I. I. BARYSHNIKOV, V. I. GENERALOV, & E. A. MUKHIN. Pharmacological characteristics of Becaptan (Beta-mercaptoethylamine) and its effects on the course and outcome of radiation sickness. Trudy Vsesoyuz. Konf. Med. Radiol., Moscow (Proc. Conf. Med. Radiology. Clinical aspects and therapy of Radiation Sickness). p.71-77, 1957. 152.

It was found that the relative toxicity of the new salts of Beta-mercaptoethylamine, the ascorbate and the nicotinate, was 0.6 compared to 1.1 for salicylate salt and 1.0 for Beta-mercaptoethylamine itself. These new salts (dose of 3 mg per mouse) were as effective as Becaptan in moderating the outcome of severe radiation sickness (700 r).

BACQ, Z. M. & M. L. BEAUMARIAGE. Inability of methionine to affect lethality in mice and rats exposed to X-rays. Nature, 186:1064, 1960. 153.

Administration of methionine in a wide range of doses produces no decrease in the mortality of mice or rats irrad. with 700 or 800 r of X-rays.

BACQ, Z. M. & A. HERVE. Chemical protection from X-radiation. Bull. Acad. R. Med. Belg., S.6, 17:13-58, 1952. 154.

The radioprotective properties of different amines, especially methylamine, ethylamine, ethanolamine, n-propylamine, histamine, aromatic amines, hydroxylamine, diamines, B-mercaptoethylamine, cystinamine, coenzyme A and amino acids, were tested. It is concluded that most amines are protective and the corresponding acids are not, that cysteinamine and its oxidation product are, at present, the best protectors. The results are explained by the theory of free radical action.

BACQ, Z. M. & A. HERVE. Co-enzyme A and ionizing radiations. Arch. Intern. Physiol. 61:434-36, 1953. 155.

An equimolecular concentration of co-enzyme A is more effective than mercaptoethylamine in protecting mice from X-irrad.

CAVALLINI, D. & L. TENTURI. Inability of thiotaurine to protect mice against ionizing radiation. Nature, 186:254, 1960. 156.

Thiotaurine gave no protection to mice given 600 r in 15 min, even in large doses.

DEVIK, F. Cytological investigation of bone marrow of mice after administration of protective agents and subsequent X-radiation. Brit. J. Radiol. 25:481-84, 1952. 157.

Prior to 200 r X-irrad. mice were treated with cysteine, glutathione, thiocholine, thiourea, ascorbic acid, methylene blue, and vit. B_{12}. None of these substances reduced the frequency of chromosomal aberration but hypoxia did.

ELY, R. E., K. M. DUNN, C. F. HUFFMAN, C. L. COMAR, & G. K. DAVIS. The effect of methionine on the tissue distribution of radioactive cobalt injected intravenously into dairy calves. J. Animal Sci. 12:394-401, 1953. 158.

500 mg methionine i.v., 2-3 min before injection of radioactive cobalt, prevented the physiological toxic symptoms observed in controls, but did not alter Co distribution in the tissues.

FUSHIMI, I., K. ITO, J. MIYAGI, & Y. KAWASAKI. Methionine indicated for irradiation injuries. Med. Assoc. Journal, Med. College, Nara, Japan, 4: no. 4, 23-26, 1953. 159.

Pre-administration of methionine (6.25 to 0.4 g/kg daily for 10 days) reduced the X-ray irrad. mortality in guinea pigs and rats.

GOLDIE, H., G. J. TARLETON, JR., & P. F. HAHN. Effect of pre-treatment with cysteine on survival of mice exposed to external and internal irradiation. Proc. Soc. Exp. Biol. Med. 77:790-94, 1951. 160.

HAGEN, U. & R. KOCH. On the mechanism of action of organic sulfhydryl compounds as protectants against irradiation. Zschr. Naturforsch. 12b: 240-49, 1957. 161.

HENNESSY, T. G. & F. B. FOLSOM. The inability of cysteine to protect erythropoietic bone marrow against radiation injury at a dose level of 800 r. Naval Radiol. Def. Lab. Rpt. AD-266(B), 1950. 162.

HENNESSY, T. G., F. B. FOLSOM, & J. K. GLOVER. The inability of glutathione to protect erythropoietic bone marrow against irradiation injury at a dose level of 300 r. NMRI Rpt. (AD-267 (B)), 1950. 163.

HOFMANN, D. The local action of cysteine in its use for active radiation protection. Strahlentherapie 96:396-402, 1955. 164.

The local protective effect is confirmed with respect to erythema of the rat tail. Subcutaneous injections of a water solution of cysteine proved to be the most effective protection, while to a certain extent, protection was obtained with cysteine ointment as well as with cystine ointment.

HOHNE, G., R. JASTER, & H. A. KUNKEL. Influence of cysteine on the radiation induced changes in serum protein of rats. Klin. Wschr. 31:910, 1953. 165.

Paper electrophoretic patterns of the serum of rats given 100 mg cysteine i.p. before exposure to 250-1000 r of X-rays indicated a definite weakening of the radiation effect.

HOPE, D. B. Thiols and radiation damage. Glutathione, p94-114. In: Biochemical Soc. Symposium no. 17, Univ. of London, 15 Feb. 1958. E. M. Grook, ed., Cambridge, England, University Press, 1959. 166.

A review. 120 references.

HORNYKIEWYTSCH, T. Physico-chemical and histochemical investigations on X-irradiation effects. Strahlentherapie 86:175-206, 1952.167.

Comparative investigations with cysteine, vit. C and methionine were conducted.

KOCH, R. Cysteine as a protector against irradiation. Arch. Exp. Pathol. Pharmakol. 225:179-82, 1955. 168.

KULIVEN, M. H. Effect of cysteine HCl on radiation induced depigmentation of mouse hair. J. Investigative Dermatol. 20:237-43, 1947. 169.

KUMTA, U. S., S. U. GURNANI, & M. B. SANASRABUDHE. Influence of post-irradiation administration of methionine on the excretion of creatine, creatinine, and N-methylnicotinamide in urine of rats. Experientia 13:372-73, 1957. 170.

Single injections of methionine 5mg/kg ½ hr after 600 r X-irrad. reduced the increased excretion of creatine and creatinine whereas similar treatment ½ hr before irrad. was ineffective. The excretion of N-methylnicotineamide was maintained at normal levels by injection of methionine either ½ hr before or after irrad.

LANGENDORFF, H., R. KOCH, & U. HAGEN. Biological protection against radiation. viii. Specificity of cysteine and various sulfhydryl compounds as protective agents. Strahlentherapie 95:238-50, 1954. 171.

Of the organic S compounds tested as protective substances against radiation effects, only homocysteine, N, N-dimethylcysteamine, and N-Beta-alanylcysteamine were effective. Cystinamine was ineffective.

LORENZ, W. Hematologic investigations on the action of cysteine. Strahlentherapie 88:190-97, 1952. 172.

McDONALD, J. E. Cysteine protection of the cornea against beta-radiation. Arch Ophthalmol. 51:310, 1954. 173.

MAISIN, J., G. LAMBERT, M. MANDART, & H. MAISIN. Therapeutic action of glutathione and mercaptoethylamine against a lethal dose of X-rays. Nature 171:971, 1953. 174.

Reduced glutathione and Beta-mercaptoethylamine were injected into rats exposed to a lethal dose of X-rays, but shielded in the liver area during exposure. Therapeutic action of both compounds was shown by the greatly increased number of survivors after 7-30 days. In a similar experiment in which an equivalent area of the costal region was protected during irrad. Beta-mercaptoethylamine did not shown therapeutic action.

MAISIN, J. & R. A. POPP. Effect of AET on sodium, potassium, and esterases of the alimentary tract of irradiated mice. Am. J. Physiol. 199:251-55, 1960. 175.

In mice given AET (S,2-aminoethylisothiouronium Br·HBr) before exposure to 1500 r, the following radiation-induced abnormalities were completely or partially corrected: decrease in potassium and increase in sodium in the wall of the small intestine; decrease in potassium in the colon wall; and increase in sodium and potassium in the contents of the stomach, small intestine and colon. Extracts from the walls of the small intestines of AET-treated or non-treated, irradiated mice were analyzed chemically for esterase activity. In AET-treated, irrad. mice, complete recovery of esterase activity was observed by day 7 after 900 r; and partial recovery occurred after 1500 r. The beneficial effects of the compound on the correction of electrolyte imbalance and esterase activity are ascribed to recovery of the tissues of the gastrointestinal tract.

MOZZHUKHIN, A. S., F. YU. RACHINSKII, & L. I. TANK. Relationship between the chemical structure and the protective effect of various mercaptoamines against X- and gamma-irradiation. Med. Radiol. 5: no 4, 78-81, 1960. (JPRS-5016 (p. 192-207)). 176.

NARURKAR, M. K., A. J. BAXI, N. S. RANADIVE, M. V. NARURKAR, & M. B. SAHASRABUDHE. Influence of post-irradiation adminstration of methionine on the levels of decxyribonucleic acid in bone marrow, spleen, and liver of rats. Nature 180:193-94, 1957. 177.

W.b. X-irrad. brings about a fall in levels of deoxyribonucleic acid in all the tissues studied, and the administration of methionine either before or after irrad. checks the fall to some extent. Post-irrad. administration of methionine is more effective. The fall in level of deoxyribonucleic acid in post-irrad. methionine treated animals was 50.6 and 51.6%, resp., in bone marrow and spleen. The values for irrad. animals without methionine treatment were 87.9 and 71.8%.

PATT, H. M., J. W. CLARK, & H. H. VOGEL, JR. Comparative protective effect of cysteine against fast neutron and gamma-irradiation in mice. Proc. Soc. Exp. Biol. Med. 84:189-93, 1953. 178.

Pre-treatment with cysteine conferred significant protection against the acute lethal effects of Co^{60} and fast neutron (fission) irrad. in mice. The protection observed with fast neutrons was about half that found with gamma irrad.

PATT, H. M., S. H. MAYER, R. L. STRAUBE, & E. M. JACKSON. Radiation dose reduction by cysteine. J. Cell. Comp. Physiol. 42:327-41, 1953. AECU-2177; UAC-610, 1952. 179.

PATT, H. M., D. E. SMITH, & E. JACKSON. The effect of cysteine upon the peripheral blood of the irradiated rat. Blood 5:758-63, 1950. 180.

PATT, H. M., E. B. TYREE, R. L. STRAUBE, & D. E. SMITH. Cysteine protection against X-irradiation. Science 110:213-14, 1949. 181.

ROSENTHAL, R. L., L. GOLDSCHMIDT, & B. J. PICKERING. Hematologic changes in rats protected by cysteine against total-body X-irradiation. Naval Radiol. Def. Lab. Rpt. AD-215 (B), 1950. 182.

SAHASRABUDHE, M. B. Modification of irradiation injury by methionine. 2d United Nations Conference on the Peaceful Uses of Atomic Energy, 23:94-100, 1958. 183.

Administration of methionine to rats half an hr after irrad. was shown to reverse the effects on DNA in bone marrow and spleen and the excretion of N-methylnicotinamide in urine.

SEMENOV, L. F. & E. A. PROKUDINA. Use of some sulfur-containing compounds in prophylaxis of radiation sickness. Med. Radiol. 1: no. 4, 70-75, 1956. 184.

SMITH, D. E., H. M. PATT, & E. B. TYREE. Progress Report: Notes on the evaluation of materials that might be expected to alter radiosensitivity. ANL-4401, p.72, 1950. 185.

Rats exposed to 1000 r w.b. X-irrad. were given BAL intramuscularly, and cysteine plus KCN, thiamine HCl, L-taurine, and tyrosine were given i.v. Only BAL and cysteine plus KCN were effective. Doses used were maximum non-lethal dose and one-half of that, controls received 5% NaCl. Thiamine HCl 75 or 150 mg/kg; L-taurine 750 or 1500 mg and tyrosine, 250 or 500 mg.

SMITH, D. E., H. M. PATT, E.B. TYREE, & R. L. STRAUBE. Quantitative aspects of the protective action of cysteine against X-radiation. Proc. Soc. Exp. Biol. Med. 73:198-200, 1950. 186.

STRAUBE, R. L. & H. M. PATT. Studies with cysteinamine and cysteine in X-irradiated animals. Proc. Soc. Exp. Biol. Med. 84:702-04, 1953. 187.

A post-irrad. protective effect of cysteinamine in rats with the liver area shielded as reported by other investigators was not confirmed. Cysteinamine is about 5 times as effective as cystine when given to mice i.v. in equimolar amounts before irrad. The 2 compounds appear to be additive in their protective effect against acute radiation lethality.

THEISMANN, H. Erythema inhibition by means of amino acids. Strahlentherapie. 96:107-10, 1955. 188.

The author described two possibilities of inhibiting the formation of radio-induced erythema by means of injected amino acids (cysteine, methionine, glycine).

VON SALLMANN, L., Z. DISCHE, G. EHRLICH, & C. M. MUNOZ. Study on penetration of cysteine and cystine into the aqueous humor of rabbits and its relation to early X-irradiation effects on the eye. Am. J. Ophthalmol. 34:95-113,1951. 189.

c. Excretion and Tissue Levels

See also nos. 65, 106, 138, 257, 258, 267, 287, 311, 337, 341, 353, 354, 369, 400, 436, 507.

AEBI, H. Taurine excretion and the influences of radiation. Bull. Schweiz. Akad. Med. Wiss. 12:336-43, 1956. 190.

After 250 or 500 r irrad. of rats, urinary taurine excretion increased within 24 hr. Normal values of 1.5-2.5 mg/100 g/24 hr were recorded by the 3d day and values were sub-normal from the 5th to 10th days. Comparable irrad. dosage from a 31 Mev betatron caused a much smaller increase in taurine excretion. Administration of cysteamine (i.p.) does not prevent this.

AEBI, H., L. BERNAYS, H. FLUCKIGER, B. SCHMIDLI, & A. ZUPPINGER. Taurine excretion by the roentgen-and betatron-irradiated rat. Helv. Physiol. Acta 13:C49-C51, 1955. 191.

AEBI, H., K. LAUBER, B. SCHMIDLI, & A. ZUPPINGER. Effects of ionizing radiation on the taurine excretion by the rat. Biochem. Zschr. 328:391-404, 1957. 192.

Daily urinary taurine excretion by rats fed a 20% casein diet was 1.7 mg/100 g body weight, X-irrad. of 250 or 500 r caused proportionate increase in excretion, i.e., +1.8 or +3.05 mg/100 g/day. Betatron-irrad. caused smaller increase of +1.0 and +1.6 mg/100 g/day.

ANGEL, C. R. & T. R. NOONAN. Urinary taurine excretion patterns in the rat, rabbit, guinea pig, and dog following exposure to whole body X-irradiation. (Abstr.) Fed. Proc. 19:353, 1960. 193.

The present study compares the urinary excretion pattern of taurine in the rat, rabbit, and guinea pig and dog for several days prior to and for 7 days after exposure to physically equivalent doses of X-irrad. The rat shows a four-fold increase in taurine on the 1st post-irrad day, with a return to normal level by the 4th day. The rabbit shows a two-fold rise on the 3d post-irrad day and approaches pre-irrad. values on the 6th day. The guinea pig shows no consistent elevation of taurine throughout the 7-day period. The dog shows no elevation of taurine for the 1st 4 days post-irrad. and then variable increases are observed on the 5th, 6th, and 7th post-irrad. days. These results indicate that the urinary excretion of taurine after w. b. X-irrad. is species dependent.

BELYAEVA, E. M., T. A. FEDOROVA, & S. S. VASILESKII. Electrophoretic study of soluble liver proteins in radiation sickness. Voprosy Med. Khim. 6:377-81, 1960. 194.

In separating, by means of paper electrophoresis, soluble proteins of the liver of rats, it has been found that in normal liver the quantity of proteins corresponding in mobility to the albumins of the blood serum equals 9.6%; alpha-globulins, 21.8%; beta-globulins, 38.8%; and gamma-globulins, 23.6%. The slow-moving fraction of liver proteins was 6.2%. A study was made of the changes in soluble liver protein contents at various periods following X-irrad. with a 650 r dose. The following was ascertained: there was a 21.3% decrease in the content of proteins that correspond in their mobility to beta-globulins of the serum; a 51.2% increase of the content of fractions corresponding in mobility to serum alpha-globulin during the 1st 24 hr; and an increase in serum gamma-globulins starting within 3 days after irrad. From the 3d to 7th day, all the above-mentioned changes showed progressive tendencies. As compared to normal liver, the content of proteins corresponding to serum beta-globulins had decreased on the 7th day after irrad. by 46.2% and those corresponding to alpha- and gamma-globulins had increased by 64.4 and 21.6%, respectively. Changes were observed in the ration of protein fractions of the blood serum that are typical for radiation sickness. These changes were reduction of the albumin content and an increase in globulin fractions.

BILLITTERI, A. & A. BERNARDINI. Serum protein in X-ray-treated guinea pigs. Boll. Soc. Med. Chir. Catania 25:310-19, 1957. 195.

Total blood protein shows statistically significant decrease on 1st and 6th days after w.b. X-irrad. 450 r. Albumin decreased progressively; alpha-globulin increased 1st day; gamma-globulin decreased initially with rapid restoration to normal values. In survivors beta- and gamma-globulin increased.

EDSALL, D. L. & R. PEMBERTON. The nature of the general toxic reaction following exposure to the X-rays. Am. J. Med. Sci. 133:426-31, 1907. 196.

Remarkable drop in excretion N, chlorides, uric acid, phosphates, after X-irrad., followed by a striking rise, in 2 patients.

FEDOROVA, T. A. Nitrogen metabolism during experimental radiation sickness in rats. All Union Conference on Medical Radiology, 1957. AEC-tr-3661 BK 1, 191-201; ... in dogs, ibid. p. 202-6, 197.

Shifts of N metabolism in rats were determined by analyses of urine for total N, urea, ammonia, amine N, creatinine and creatine. Effect of w.b. irrad. on digestion and assimilation of protein foods and effects of X-rays on enzymatic systems were also studied. Negative N balance was noted soon after exposure. Creatinuria was observed. X- and gamma-irrad. effects were studied in dogs. Increased tissue breakdown was observed.

FASTYUCHENKO, O. V. & B. M. VARSHAVSKII. Changes in some indices of protein metabolism on chronic and acute action of ionizing radiation. All Union Conference on Medical Radiology, 1957. AEC-tr-3661 BK 1:224-26. 198.

Changes of protein metabolism were observed in rabbits following both chronic and acute irrad. After acute irrad., changes were observed within several hr. Protein metabolism was not restored to initial values for a period of several months. In chronic irrad., changes continued for several months after discontinuation of irrad.

GOLDWATER, W. H. & C. ENTENMAN. Nature of serum protein changes in the X-irradiated dog. Am. J. Physiol. 188:409-14, 1957. 199.

Serum protein, lipoprotein and glycoprotein patterns have been studied in irrad. dogs, using paper electrophoresis techniques. Alpha-1 globulin lipid decreases in the terminal stages following fatal doses of X-irrad. and beta-globulin lipid increases slightly. Loss of alpha-4 and gain of alpha-3 glycoproteins, have been found as early as 10 days prior to irrad. death, and in the absence of lipoprotein or body temperature abnormalities.

GRAEVSKAYA, B. M. Some changes in protein metabolism in animal organism after local and general X-ray irradiation. Vestn. Rentgenol. Radiol. 28: no 5, 9-14, 1953. 199a.

HALLESY, D. W. & J. DOULL. Effect of whole-body X-irradiation on the free amino acid content of rat plasma. (Abstr.) Fed. Proc. 15:433, 1956. 200.

Adult male rats were given 800 r w. b. X-irrad. Both control and irrad. animals were fasted during the post-irrad. period to eliminate the effects of the radiation-induced anorexia. The plasma content of serine, glutamic acid, valine, methionine, lysine, alanine, threonine, isoleucine, and leucine was increased at 24 hr after the X-ray exposure. The plasma levels of tryptophan, arginine, and aspartic acid were unchanged and that of glycine was decreased. These effects were transitory lasting only about 24-48 hr except for the increase in the amounts of threonine, isoleucine, and leucine and the decrease in the quantity of glycine which persisted throughout the 5-day observation period.

HUNTER, C. G. Amino aciduria in primates following irradiation. Proc. Soc. Exp. Biol. Med. 96:794-96, 1957. 200a.

Four rhesus monkeys, 1 exposed to X-irrad. and 3 to gamma-irrad., were studied. In 2 non-survivors there was little change in the daily quantity excreted except terminally. In 2 survivors, daily N excretion differed, but slightly during 1st wk., from values at irrad.; 2d wk., more amino N was excreted by one animal, less by the other. Amino aciduria in primates irrad. with doses in lower lethal range is inseparable from the natural response of the overall protein metabolism associated with any injury.

JEHOTTE, J. Nitrogen balance of rats subjected to lethal X-irradiation. Compt. Rend. Soc. Biol. Paris, 148:941-43, 1954. 201.

N excretion immediately falls after 800 r X-irrad. of rats; it then rises the 5th post-irrad. day to fall again briefly before death. Fasting does not modify the N excretion pattern of the irrad. rat.

KATZ, E. J. & R. J. HASTERLIK. Amino aciduria following total-body-irradiation in the human. J. Natl. Cancer Inst. 15:1085-1107, 1955. 202.

Following the accidental exposure of 4 laboratory workers to w.b. irrad. with gamma-rays and neutrons at levels between 25 and 180 rep (roentgens equivalent physical), total daily urinary amino acid excretion increased to as high as 10 times normal values. The quantities of individual amino acids excreted varied from 2 to 20 times normal amounts. The most marked excretion occurred with hydroxy-proline and glycine. Abnormal excretion in both number and quantity of amino acids occurred as early as 12 hr following the initial exposure, and abnormal amino acid levels were evident 5 months following exposure.

There was no direct quantitative relationship between the radiation level and the degree of amino aciduria.

KAY, R. E., J. C. EARLY, & C. ENTENMAN. Increased urinary excretion of taurine and urea by rats after X-irradiation. Radiation Res. 6: 98-109, 1957. 203.

The effect of w.b. X-irrad. on the daily and hourly excretion of urea, taurine, sulfate, and creatinine was investigated in the fasting rat. Exposure results in an increase in the daily excretion of taurine, urea, and sulfate, but not in the daily excretion of creatinine. At all doses investigated (75 to 2500 r) the greatest excretion of urea and taurine was evident on the day following irrad. For doses up to 250 r the daily excretion of taurine, urea, and sulfate increased with increasing dose, while at doses greater than 250 r there was no further increase. Excessive taurine and urea excretion was evident within 3 hr and peak excretion rates occurred 5 hr after irrad. Thereafter, the hourly elimination of taurine declined rapidly, while that of urea decreased gradually. Adrenalectomy prevented the daily increases in urea and sulfate excretion, but did not prevent the increase in taurine excretion.

KAY, R. E. & C. ENTENMAN. The effect of multiple dosages and partial-body X-irradiation on urinary taurine excretion by the rat. Radiation Res. 11:357-69, 1959. USNRDL-TR-329, 19 204.

The effect of multiple dosages, shielding and organectomies on the hourly and daily excretion of taurine following X-irrad. was studied in the fasting rat. Pancreatectomy prevented the excessive excretion of taurine.

KAY, R. E. & C. ENTENMAN. Free amino acids in the tissues and urine of the X-irradiated rat. (Abstr.) Fed. Proc. 13:520, 1954. 205.

After 800 r or 2500 r of 250 KVP w.b. X-irrad. of rats, the concentration of taurine, glutathione, cysteic acid, methionine, citrulline and leucine increased in the urine. Taurine concentration in urine increased 5-fold; daily excretion 10-fold. Glutathione, cysteic acid concentration increased 2-fold; excretion 4-fold. 60 hr after 2500 r X-irrad. concentrations of amino acids in tissues and serum were greatly altered as follows: serum -- increase of cysteic acid, glutathione, methionine, and alanine concentration; muscle -- increase of methionine, glycine, cirtulline, and phenylalanine; adrenals -- increase of glutathione; liver -- decrease of glutathione, cysteic acid, taurine, glycine, glutamic acid, and alanine; kidneys -- decrease of taurine, glycine, glutamic acid, citrulline.

KAY, R. E., D. C. HARRIS, & C. ENTENMAN. Urinary excretion and plasma levels of free ninhydrin reactive compounds in X-irradiated rats. Am. J. Physiol. 186:175-79. 1956. USNRDL-TR-53, 1955. 206.

In urinary excretion studies, fasted rats were exposed to 450 or 2500 r X-irrad. During the day after irrad. urinary excretion of taurine, cysteic acid, leucine, and valine rose. Plasma studies were made on rats 6, 12, 24, and 30 hr after 600 r w.b. X-irrad. Transitory elevations of lysine, glutamine, taurine, methionine, valine and leucine were seen. No change was recorded for arginine, serine plus glycine, threonine, alanine, and creatinine.

KRETCHMAR, A. L. An alteration in the excretion of free serine in urine from irradiated humans. Nature 183:1809-10, 1959. 207.

A decrease in urinary free serine was noted in 8 men exposed to high level w.b. gamma and neutron irrad. In some cases it was totally absent. Reduction was also seen in a leukemic child given 800 r Co^{60} irrad.

KUMTA, U. S., S. U. GURNANI, & M. B. SAHASRABUDHE. The fate of methionine-S^{35} in irradiated rats. J. Sci. Ind. Res. (India) 16C:111-13, 1957. 208.

Methionine-S^{35} was administered to rats ½ hr before w.b. X-irrad. The free amino acid pool of the irrad. group showed a 58% reduction in S^{35} activity over the controls. A considerable proportion of the radioactivity was excreted in the urine in the form of inorganic salts. The activity of the inorganic sulfate fraction was 5 times greater in irrad. rats than in controls.

LINDER, E. The effects upon the properdin system of ionizing radiation. Strahlentherapie 103:91-97, 1957. 209.

After w.b. irrad. rats with 500 r, there is rapid decrease of the properdin by 2/3. independent of the hardness of the radiation (250 KV X-ray or 31 mev betatron.)

LUZZIO, A. J., G. SUTTON, & J. G. KEREIAKES. Blood and urine tyrosine levels in starved X-irradiated rats. Proc. Soc. Exp. Biol. Med. 97:593-95, 1958. 210.

Alterations in serum and urine tyrosine levels were observed in starved irrad. rats and in starved control rats. It appears that protein catabolism is somewhat slower following irrad. at the 800 r level used.

MEFFERD, R. B. & H. H. MARTENS. Excretion patterns of rats following total-body exposure to X-radiation. Science 122:829-30, 1955. 211.

Analyses were made on 24 hr fasting urine samples at 3, 1, 5, 9, 13, 17, 23, and 29 days after 550 r w.b. X-irrad. ($LD_{42/30}$) of rats fed Purina. Data were pooled as groups surviving 30 days (I), 14 (II) or 11 (III) days. Urine volumes and excretion of most compounds became elevated in all groups. Glycine was subnormal throughout the post-irrad. period, while taurine, valine, and aspartic acid were for the most part, subnormal after the 1st day. Urea and alanine were elevated during the entire period. Histidine and aspartic acid decreased progressively from group I to II to III, and the uric acids of the non-survivors were significantly greater than those of group I. The metabolic differences among survivors vs. non-survivors are detectable within 24 hr after exposure. Short-term survivors had the lowest individual pre-irrad. values of the 12 rats in urine volumes, phosphate, creatinine, urea and uric acid.

OAK RIDGE INST OF NUCLEAR STUDIES. Oak Ridge, Tenn. Med. Div. Rpt. for 1959. Contr. AT-40-1-Gen-33. 212.

Data are tabulated on daily variation in levels on urinary amino acids and the effects of w.b. irrad. on urinary excretion of amino acids.

OGASAWARA, K. & J. NAKAMURA. Effects of X-ray irradiation on tryptophan metabolism. Wakayama Med. Rpts. 5:9-20, 1960. 213.

Abnormalities in tryptophan metabolism due to X-irrad. indicated that the formation of oxides caused obstruction to the hepatic enzyme system that is active in tryptophan metabolism.

PALMER, R. F. & M. F. SULLIVAN. Effect of intestinal tract irradiation on serum proteins of the rat. Proc. Soc. Exp. Biol. Med. 101: 326-28, 1959. 214.

Albumin content of rat serum after irrad. of the intestinal tract only is affected in the same manner as it is by w.b. irrad.

PENTZ, E. I. Factors influencing the excretion of taurine in irradiated rats with particular reference to the adrenal glands. J. Biol. Chem. 231:165-174, 1958. 215.

Normal rats exposed to 600 r showed an increase of taurine excretion 3 times that of non-irrad. controls on the day after exposure, when the water intake was restricted for 6 hr immediately after irrad,; 48 hr after exposure taurine excretion levels had returned to normal. In adrenalectomized rats after 400 r X-irrad. excretion of taurine was double that of unilaterally nephrectomized and control animals subjected to sham operation receiving the same amount of X-irrad. Taurine excretion did not return to normal levels in adrenalectomized animals. Removal of thymus and spleen did not reduce the amount of taurine excreted after 400 r w.b. X-irrad.

V. L I P I D S

(Includes fat, fatty acids, fatty alcohols, cholesterol and phospholipid)

A. CLINICAL STUDIES

See also no. 221.

BROHULT, A. Alkoxyglycerols in the treatment of leukopaenia caused by irradiation. Nature 174:1102-03, 1954. 216.

Treatment with alkoxyglycerols administered by mouth proved effective in raising the white blood count of patients suffereing from radio-induced leukopenia.

BURGHEIM, F. Newer investigations into the pathogenesis and therapy of radiation sickness. Strahlentherapie 27:297-305, 1927. 217.

In 78 cases of radiation sickness cholesterin content of blood decreased. This is thought to be the primary cause of radiation sickness. Tablets containing 0.1g cholesterin with small supplement of lecithin to accelerate absorption were very successful in radiation sickness therapy. Two tablets were given immediately after radiation and on the following days 1-2 tablets were given only when radiation sickness was observed.

WAEGNER, A. The fight against radiation sickness. Deutsch. Med. Wschr. 55:316, 1929. 218.

Cholesterin with lecithin was administered in form of tablets fabricated after instructions given by Burgheim. Two tablets were given before and after treatment and then 2 to 4 times hourly with good success in preventing radiation sickness after radiation therapy for a variety of conditions.

B. LABORATORY STUDIES

1. Dietary variation and peroral administration

See also nos. 114, 128, 134, 135, 151, 343, 378.

ANON. Radiation damage and fat deficiency. Nutrition Rev. 14:54-5, 1956. 219.

A review of the several papers from Deuel's laboratory.

ARTOM, C. & H. B. LOFLAND, JR. Dietary fats and effects of internal radiation by P^{32}. Proc. Soc. Exp. Biol. Med. 104:396-99, 1960.220.

Mice were maintained on various experimental diets and injected with single dose of radioactive phosphate (4 to 5 microcuries/g). Higher % of survivors and longer survival time were observed in animals on fat-free diet as compared with those fed diets containing 30% corn oil, or 30% hydrogenated coconut oil. However, with these high-fat diets, as well as with diets containing only minimal amounts of fat, a better survival was demonstrable when highly unsaturated fatty acids were present. It appears that, if definite amounts of these fatty acids are included, a low-fat diet should be beneficial in alleviating effects of internal radiation by P^{32}.

BROHULT, ASTRID. Effects of alkoxyglycerols and especially selachyl alcohol on the bone marrow in connection with irradiation treatment and in leukemia therapy. Nature 181:1484-85, 1958. 221.

Alkoxyglycerols reduced leukocytopenia and thrombocytopenia when given to rats before or after irrad. A comparative study was made of the effectiveness when administered as natural shark-liver oil and as purified concentrate of esters. Selachyl alcohol showed more marked effects on bone marrow activity than any other constituent of the shark-liver oil. The alkoxyglycerols were tried in about 30 cases of acute leukemia in children, and some favorable responses were observed.

CHENG, A.L.S., R. B. ALFIN-SLATER, & H. J. DEUEL, JR. The effect of fat level of the diet on general nutrition. xiii. The effect of increasing dosages of X-irradiation on the protective action of fat on radiation injury. J. Nutrition 54:201-07, 1954. 222

Male rats received successive doses of w.b. X-irradiation of various degrees (300 to 1200 r) at varying intervals (33 series of tests). Survival time of rats receiving commercial casein but otherwise fat-free diet was considerably longer than that of rats receiving same diet made with vit.-test casein; survival was still more prolonged with addition of 15% of cottonseed oil. Protective effects of fat was equally satisfactory for rats fed only 3 weeks or 8 weeks after weaning with test diets.

CHENG, A. L. S. & H. J. DEUEL, JR. Fat protection in X-radiation injury. (Abstr.) Fed. Proc. 12:410, 1954. 223.

Rats were given a fat-free diet high in B-vit. and ascorbic acid without or with 10% defatted liver powder. These diets were further supplemented for 8 weeks with two levels of cottonseed oil or hydrogenated coconut oil prior to weekly X-irrad. (500 r for 2 weeks, 200 r for 8 weeks). Survival was improved by liver powder, cottonseed oil, and a combination of these. No benefit was derived from the hydrogenated coconut oil.

CHENG, A. L. S., T. N. GRAHAM, R. B. ALFIN-SLATER, & H. J. DEUEL, JR. The effect of fat level of the diet on general nutrition. xv. Comparison of the protective effect of linoleic acid and linolenic acid against multiple sublethal doses of X-irradiation. J. Nutrition 55:647-53, 1955. 224.

Rats were fed a fat-free depletion diet for 6 weeks after weaning; then supplements of ethyl laurate, methyl linoleate, or ethyl linolenate were administered. After 2 weeks of supplemented diets, 200 r X-irrad. was given weekly for 7 weeks. Linolenic acid alone had only slight protective effect. Minimum level of linolenate (10 mg) administered together with minimum level linoleate (10 mg) markedly increased protective action, suggesting that synergism exists.

CHENG, A. L. S., G. D. KRYDER, L. BERQUIST, & H. J. DEUEL, JR. The effect of fat level of the diet on general nutrition. ix. The relationship of radiation injury in the rat to the fat content of the diet. J. Nutrition 48:161-82, 1952. 225.

There were no differences in radiosensitivity of rats fed various diets for 3-4 weeks before single exposures of 650 and 850 r X-irrad. Rats on high-fat diet were more resistant to 2400 r X-irrad. accumulated in 300 r doses over 10-14 weeks than were those on a fat-free diet.

CHENG, A. L. S., M. RYAN, R. B. ALFIN-SLATER, & H. J. DEUEL, JR. The effect of fat level of the diet on general nutrition. xi. The protective effect of varying levels of ethyl linoleate against multiple sublethal doses of X-irradiation in the rat. J. Nutrition 52:637-43, 1954. 226.

200 r X-irrad. per week for 10 weeks were given to rats after 8 weeks of test diet feeding. Comparison of periods required for LD_{25}, LD_{50}, and LD_{75} shows that protective effect of ethyl linoleate becomes greater with increasing dosage of compound. The optimum dosage for protection in male rats probably exceed 100 mg/day.

DECKER, A. B., D. L. FILLERUP, & J. F. MEAD. Chronic essential fatty acid deficiency in mice. J. Nutrition 41:507-21, 1950. 227.

In the stateof chronic essential fatty acid deficiency in mice death may result from stress conditions including X-irrad.

DEUEL, H. J., JR., A. L. S. CHENG, G. KRYDER, & M. E. BINGEMANN. Protective effect against X-irradiation of methyl linoleate. Science 117:254-55, 1953. 228.

Rats supplemented perorally with 10 mg of methyl linoleate daily survived significantly longer following 2400 r X-irrad. (accumulated in increments of 300 r over 14 weeks) than did untreated controls on a fat-free diet.

EDLUND, T. Protective effect of d, l-α-octadecylglycerolether in mice given total-body X-irradiation. Nature 174:1102, 1954. 229.

Batyl alcohol was found to have a beneficial therapeutic effect on irrad. injuries in mice.

ERSHOFF, B. E. Effects of low-fat diets on survival time of mice exposed to multiple sublethal doses of total-body X-irradiation. Radiation Res. 13:704-11, 1960. 230.

After 6 weeks of feeding a purified, fat-free diet alone or with various supplements, mice were exposed to 200 r X-irradiation once weekly until 1600 or 2000 r were accumulated. The same diets were fed 100-150 days after the 1st exposure or until death. Survival time was increased by supplementation with cottonseed oil, 10%; methyl linoleate, 1%; dessicated liver, 10%; residue from azeotropic extraction of liver with ethylene dichloride, 1%; and heptane- or chloroform-extracted dessicated liver, 10%. Ineffective were: ethylene dichloride-extracted liver, 10%; hydrogenated coconut oil, 10%; antibiotics; water-soluble liver concentrate; bile salts; and cholesterol.

GOLDWATER, W. H. & C. ENTENMAN. Influence of diet fat on post-irradiation growth and food utilization in the rat. USNRDL-TR-351, 1959. (Abstr.) Fed. Proc. 18:55, 1959. 231.

Rats were given 3 biweekly doses of 300 r radiation and fed diets containing 19% protein from skim milk powder and 0, 37, or 68% of calories as butter-fat or corn oil. Performance was poorest on the fat-free diet. The least adverse effects of radiation were seen in rats on the high butter-fat diet.

NESTERIN, M. F. & V. N. CHUKAEVA. The course of radiation sickness and the state of the secretory function of the intestine in dogs in the employment of diets with a qualitatively different fat composition. Med. Radiol. 5: no. 7, 42-45, 1960. 232.

Diets contained 30% fat from suet, sunflower oil, sour cream, or fat enriched with arachidonic acid. Less disturbance of intestinal secretory processes was seen in dogs given sour cream or fat fortified with arachidonic acid.

2. Parenteral administration

ASHIKAWA, J. K. Post-irradiation protection of mice with lipids. (Abstr.) Radiation Res. 12:418, 1960. UCRL-8988, 1959. 233.

Olive oil protects lethally irrad. male Swiss mice if it is administered i.p. within 1 hr after irrad. Effect is manifested during bone marrow phase by an increase in survival, change in mortality distribution and decrease in weight loss. Suggested effect due to stimulation of the reticulo-endothelial system. Effect suppressed by increasing stearate content of oil. Methyloleate has some beneficial effect.

ASHIKAWA, J. K. & O. K. ANDERSON. Post-irradiation protection of X-irradiated mice with olive oil. Radiation Res. 13:99-107, 1960. 234.

A single i.p. dose of ml of olive oil was both protective (1 hr before) and therapeutic ($\frac{1}{2}$ hr after) to lethally X-irrad. mice ($LD_{50/30}$ and $LD_{99/30}$). Pre-irrad. injection of lycopene had a questionable effect; post-irrad. administration was harmful.

MOELLER, H. C. & J. M. VAETH. Evaluation of fat emulsion in the acute irradiation syndrome in rats. (Abstr.) Fed. Proc. 19:223, 1960. 235.

Rats, 120 days old, were subjected to an $LD_{50/30}$ dose of w.b. X-irrad. (250 KV). The fat used was a 15% cottonseed oil emulsion administered i. p. One group of rats received 1 g and a second group 2 g of the fat emulsion per kg body weight daily for 14 days following irrad. In each experiment a control group of rats were given an equal volume of 5% dextrose in water. Mortality was definitely increased in the rats that received 2g daily of the fat emulsion.

WHITE, S. G., J. B. LAGEN, P. M. AGGELER, & R. P. GEYER. Effect of soybean phosphatide on blood coagulation defect following total body X-irradiation in the dog. Proc. Soc. Exp. Biol. Med. 83:384-87, 1953. 236.

Thrombocytopenia, prolonged whole blood clotting time, and markedly impaired clot retraction and prothrombin utilization were induced in dogs, by 150 r w.b. X-irrad. A marked increase in prothrombin utilization was found after addition of a soybean phosphatide solution to the blood in vitro. A temporary decrease in the clotting time and an increase in prothrombin utilization without change in the platelet count or clot retraction, was induced by i.v. infusion of 20-100 ml of a 2.5% solution of the phosphatide in the irrad. dogs.

C. TISSUE LEVELS

See also nos. 72, 73, 77, 102, 106, 217, 253, 257, 258, 287, 496.

BHATT, I. N., T. A. VENKITASUBRAMANIAM, & R. VISWANATHAN. Effect of gamma-irradiation on blood lipids. Experientia 16:537, 1960. 237.

Rats were given 800 r w.b. irrad. from a Co^{60} source. Total blood lipids had increased 38.8% 24 hr after irrad. Cholesterin and phospholipid concentrations were unchanged.

CONIGLIO, J. G., W. J. DARBY, A. EFNER, E. BELL, D. B. McCORMICK, & G. W. HUDSON. The effect of X-irradiation on fat metabolism. International Conference on Peaceful Uses of Atomic Energy, 11: 306-10, 1956. 238.

CORNATZER, W. E., J. P. DAVIDSON, O. D. ENGELSTAD, & C. SIMONSON. Effect of whole body X-irradiation on lipids in the liver, kidney, and spleen of fasted rats. Proc. N. Dak. Acad. Sci. 8:22, 1953, Radiation Res. 1:546-50, 1954. 239.

ENTENMAN, C., R. A. NEVE, H. SUPPLEE, & C. A. OLMSTED. Effects of X-irradiation on lipid metabolism. 1. Plasma phospholipide levels in several species. Arch. Biochem. Biophys. 59:97-105, 1955. 240.

Levels are elevated following irrad. of rats, dogs, mice, rabbits, and guinea pigs, but there are species differences in magnitude and duration.

HOLMES, B. E. Serum cholesterol and irradiation sickness. Brit. Med. J. 1:314, 1941. 241.

The data presented were obtained by serum analysis in 11 cases under X-ray therapy. The findings are incomplete but information points to the conclusion that patients who suffer no post-irrad. discomfort have a rise in cholesterol serum content and that those who have a typical gastric upset following irrad. fail to show this rise.

LEVY-DORN, M. & F. BURGHEIM. Effect of X-irradiation on the cholesterin content of the blood in the healthy and diseased body. Strahlen-therapie 22:538-49, 1926. 242.

In patients with malignant tumors the blood cholesterin content increases after irrad., contrary to the decrease in blood cholesterin observed in patients that received radio-therapy for other diseases. In carcinoma cases the cholesterin content of 1 cc whole blood was smaller than the amount found in 1 cc serum, opposite to the results found for patients treated for other diseases.

MEFFERED, R. B., JR., W. W. WEBSTER, & M. A. NYMAN. Lipid metabolism in X-irradiated mice and rats. Radiation Res. 8:461-65, 1958. 243.

X-irrad. male rats (500 r) and mice (425 r) showed significant changes in the specific activities of total non-saponifiable lipids, cholesterol (digitonide-preciptated), and fatty acids. The latter were elevated by day 6, but by day 9 or 15 (mice and rats, respectively) these had returned to control levels. The specific activities of the cholesterol were less variable, but they were significantly low on day 9 in the mice and day 15 in the rats. Cholesterol and fatty acid metabolism were quite different, and in the latter the metabolism of the solid and liquid fatty acids were quantitatively different.

VI. C A R B O H Y D R A T E

A. CLINICAL STUDIES

FOCHEM, K. Comparative studies of therapeutic possibilities in radiation sickness. Wien. Med. Wschr. 105:929-32, 1955. 245.

Levulose (as laevosan) could not be given by mouth because of gastrointestinal disturbances; daily injections prevented radiation sickness and leukopenia. Combined with vit. C it protected the hepatic system and caused weight increase. Bilamid-cholin (a liver protective preparation) given by mouth, 0.5 g daily, resulted in prevention of radiation sickness, leukopenia, and weight loss; it protected the hepatic system, stimulated appetite; there were no effects on tumor growth and a faster recovery. Compared to laevosan, Bilamid-cholin is much preferable.

FOCHEM, K. The effect of levulose on radiation sickness. Strahlentherapie 93:466-72, 1954. 246.

Fructose can be used in radiation sickness to detoxicate the liver and diminish unpleasant side effects. The damage to the liver during high dosages of X-irrad. and the therapeutic effects of fructose were determined by means of the bromosulfophthalein test.

FOCHEM, K. The problems and therapy of radiation sickness. Strahlentherapie 93:307-16, 1954. 247.

Studies in 270 patients undergoing radiotherapy. Treatment with levulose is recommended.

B. LABORATORY STUDIES

See also nos. 115, 117, 151, 330, 378.

BACLESSE, F. & J. LOISELEUR. Modification of the cutaneous radiosensitivity of the rabbit in the course of experimental hyperglycemia. Compt. Rend. Soc. Biol. Paris, 141:743-45, 1947. 248.

Skin sensitivity to X-rays was diminished by intramuscular administration of a large dose of glucose 45 min in advance.

DUPLAN, J. F. & A. J. ROSENBERG. The protective action of glucosamine against the lethal action of total action of total X-irradiation of mice. Compt. Rend. Acad. Sci. Paris, 239:116-17, 1954. 249.

Mice were injected i.p. with a dose of 300 mg/kg of glucosamine prior to X-irrad. (580 and 700 r). The glucosamine caused a significant reduction in mortality when injected 5 min before irrad. Injection 20 min before irrad. had no effect. Metabolites of glucosamine (glucose, fructose, hexose diphosphate, and glutamic acid) displayed no protective action.

LANGENDORFF, H., R. KOCH, U. HAGEN, & H. SCHARNBECK. Investigations on biological radiation protection. xii. Radiosensitivity effects of carbohydrates. Strahlentherapie 99:121-28, 1956. 250.

Diverse hexoses and pentoses have no influence on the sensitivity towards X-rays of rats and mice. Pyruvate, oxy-butyrate, and keto-glutarate increase the resistance. An acid coma provoked by pyruvic acid or beta-oxybutyric acid and the entailed hypoxia have no effect on the resistance. The influence of alloxan diabetes is not considerable.

LOISELEUR, J. & G. VELLEY. Immunity conferred by hyperglycemia against X-rays administered in a lethal dose. Compt. Rend. Acad. Sci. Paris, 231:182-84, 1950. 251.

Rats exposed to 950 r X-irrad. lost 30% body weight and all died. I.p. injection of 2 g of glucose reduced mortality to 5/27 and promoted weight gains. Blood sugars were 102 and 145 mg %, respectively.

PANY, J. The action of levulose in combination with B complex vitamins in irradiation damage. Wien. Zschr. Inn. Med. 38:237-40, 1957.252.

Experiments were made on i.p. injection of levulose or levulose-B complex vit. combinations in intervals of 2 days after 500 r irrad. in rats. Levulose alone and levulose in combination with B complex leads to erythrocyte increase only after 10-12 days. Combination of levulose with folic acid and vit. B_{12} leads to immediate increase in erythropoesis with high survival.

C. TISSUE LEVELS

See also nos. 65, 102, 273, 275, 287, 311, 332, 337, 422, 496, 536.

CONIGLIO, J. G., J. C. KIRSCHMAN, & G. W. HUDSON. Hepatic glycogen, lipogenesis and glucose-6-phosphatase in X-irradiated and control rats. Am. J. Physiol. 191:350-54, 1957. 253.

Incorporation of C^{14} acetate into hepatic fatty acids increased in irrad. fasted rats (750 r w.b. X-irrad.) compared to fasted controls as early as 6 hr post-irrad. At this time hepatic glycogen in irrad. animals was lower than in controls and lower than in irrad. animals at 30 min post-irrad. Incorporation remained constant at 12 hr post-irrad. but glycogen concentration in irrad. rats was increased over controls. At 18 hr the irrad. rat exhibited both increased hepatic glycogen and increased lipogenesis. The increase in liver glycogen in irrad. fasted rats could be prevented effectively by administration of S, beta-aminoethylisothioronium bromide 10 min prior to irrad. Assay for hepatic glucose-6-phosphatase at 0.5, 24 and 48 hr after 750 or 1000 r w.b. X-irrad. revealed no significant change due to the irrad.

KEILINA, R. YA. The effect of total roentgen irradiation on the glycogen content in the rat liver. Biokhimia 24: no. 6, 966-69, 1959. 254.

KENT, S. P. Effect of X-irradiation on glycogen content and histology of the rabbit retina. (Abstr.) Fed. Proc. 17:442, 1958. 255.

KENT, S. P. & A. A. SWANSON. Effects of high intensity X-irradiation on the retina: A histologic, histochemical, and chemical study in the rabbit. Radiation Res. 6:111-20, 1957. 256.

The retinae of 90 rabbits were examined chemically and histochemically for succinic dehydrogenase and glycogen. They were also examined histologically. Forty-five of the animals received 6000 r of X-irrad. to the eyes. Forty-five were non-irrad. controls. Five irrad. and 5 non-irrad. control animals were sacrificed by decapitation ½, 1, 2, 4, 6, 12, 24, 48, and 72 hr after irrad. Morphologic changes consisting largely of pyknosis in the outer nuclear layers and fragmentation of the visual cell layers were first noted 4 hr post-irrad. These changes were noted in all subsequent irrad. groups. The glycogen content, particularly of the visual cell layer, increased in the 4-hr irrad. group while the succinic dehydrogenase activity decreased. Both changes were noted in all subsequent irrad. groups.

KOHN, H. I. Changes in blood plasma of guinea-pig during acute radiation syndrome. Am. J. Physiol. 162:703-08, 1950. 257

Studies were made during 8 days following 200 r to 600 r w.b. X-irrad. Elevation of sugar, NPN, chloride and cholesterol were seen at some intervals; total protein concentration fell.

KOHN, H. I. Changes in composition of blood plasma of the rat during acute radiation syndrome, and their partial mitigation by dibenamine and cortin. Am. J. Physiol. 165:27-42, 1951. 258.

Changes in plasma occurred in 2 phases, magnitude varying with radiation dose. Substances affected were: sugar, NPN, phosphorus, chloride, cholesterol, total protein, A/G ratio.

McKEE, R. W. Effects of X-irradiation on liver glycogen and blood sugar. (Abstr.) Fed. Proc. 11:256,1952. 259.

ROSS, M. H. & J. O. ELY. Radiation effects on liver glycogen in the rat. J. Cell. Comp. Physiol. 37:163-73, 1951. 260.

ROTHER, J. On the point of attack of X-ray effect on the organism. Experimental study on the analysis of the phenomenon of blood sugar changes through X-rays. Strahlentherapie 27:197-256, 1928. 261.

SHERAMET, Z. I., V. M. MANTEYFEL, & M. O. RAUSHENBAKH. Change in the mucopolysaccharides and the hyaluronidase inhibitor in the blood and tissues of animals in acute radiation sickness. Med. Radio. 4: no.12, 25-35, 1959. JPRS-2743, p.36-52. 262.

THOMPSON, H. E. & L. T. STEADMAN. The effect of whole body X-irradiation on the blood glucose levels in rabbits. UR-152:13-33, 1951. 263.

Glucose levels are elevated.

TOROPOVA, G. P. The content of glycogen in the liver of irradiated rats in parenteral administration of glucose. Voprosy Pitania 17: no, 5, 54-59, 1958. 264.

In mature and growing rats irrad. (650 r, X) intensifies the glycogenic function during the first 3 days, and retards glycogen storage at a later stage (6th day). Disturbance occurs earlier and is more pronounced in young animals. In adults, liver glycogen can be increased in stage 2 by glucose administration but not in growing rats.

TOROPOVA, G. P. The effect of hunger on liver glycogen metabolism in radiation sickness of animals. Voprosy Pitania 17: no. 1, 50-54, 1958. 265.

Decreased liver glycogen following irrad. was due to decreased food intake, proved by paired-feeding experiments.

VII. MINERALS AND WATER

A. CLINICAL STUDIES

See also nos. 330, 411.

GOLDEN, R. The alkali reserve in roentgen ray sickness. Arch. Internal. Med. 30:629-37, 1922. 266.

Administration of sodium bicarbonate was ineffective.

GOLDMAN, D. Metabolic changes occurring as the result of deep roentgen therapy. i. The effect of 200 kilovolt roentgen therapy. Am. J. Roentgenol. Radium Therap. 50:381-91, 1943. 267.

Patients with "sodium chloride starvation" showed increased susceptibility to radiation sickness and some were benefited by administration of NaCl. There was an increase during periods of therapy in total and uric acid N excretion and in total acidity of urine, followed by retention of amino acid N after radiation was stopped.

LANGE, S. The cause and prevention of constitutional sickness following the roentgen therapy. Am. J. Roentgenol. 3:356-58, 1916. 268.

A lowering of alkali reserve was postulated and administration of sodium bicarbonate found to be beneficial.

B. LABORATORY STUDIES

1. Dietary variation and peroral administration

See also nos. 117, 390.

CONSTANT, M. A. & P. H. PHILLIPS. Effect of diet and trace minerals on erythrocyte fragility and X-irradiation mortality in rats. Proc. Soc. Exp. Biol. Med. 85:678-82, 1954. 269.

Diet 1: rockland guinea pig diet (17% protein, 2.5% fat); diet 2: 45% cornflakes, 20% wheat flakes, 12% soy bean oil meal, 12% meat scraps, 5% alfalfa, 3% brewers yeast, 3% fish solubles, and 0.01% irrad. yeast (22% protein, 3% fat); diet 3(semisynthetic); 18% crude casein, 4% salts iv, 68% sucrose, 10% corn oil or Crisco, and vit. B. All rats received 2 drops of "haliver" oil weekly and were fed ad lib. Mineral supplements were: 0.5 or 1.0 mg Co; 0 to 2.0 mg Cu; and 0 to 7.5 mg Mn per 10 of ration. Animals fed diet 1

succumbed to radiation (700 r w.b. X) more rapidly. Long term feeding of polycythemic levels of Co increased the mortality rate of animals given w.b. irrad.

FRANCE, H. Changes in water content and distribution in rats and mice after chronic and acute total-body X-irradiation. In: Biological effects of external X- and gamma-irradiation. Part 2, Chap. 22, R. E. Zirkle, ed. Aug. 1956. (TID-5220.) CH-3889, 1946. 270.

Mice deprived of drinking water for 24 to 40 hr prior to irrad. show prolonged survival time but not decreased mortality. Data on tissue fluids are given.

PARR, W., T. O'NEILL, S. BUSH, & A. KREBS. Further investigations into the modification of radiation sensitivity afforded by cobalt. Science 119:415-16, 1954. 271.

The administration of a cobalt diet for 5 and 8 days before and for 15 days after X-irrad. increased the tolerance of female mice to w.b. X-irrad. (720 r). The administration of a cobalt diet for 36 days before and for 15 days after irrad. and the administration of a cobalt diet for 30 days beginning immediately after irrad. produced no pronounced beneficial effects.

PARR, W., T. O'NEILL, & A. KREBS. A study of the X-irradiation protection afforded by cobalt. Science 117:155-56, 1953. 272.

Cobaltous ion protects against irrad. if given for short periods (5 to 8 days prior to irrad.).

STEADMAN, L. T. The immediate causes of early death in lethally X-irradiated rabbits, and suitable therapy. (Abstr.) Radiation Res. 7:453, 1957. 273.

Rabbits given w.b. doses of 800 to 1600 r of 200-kvp X-irrad. occasionally die at the end of the exposure with only the symptoms of shock. Depending on the dose, 3 to 15% of the animals may succumb at 2 hr with a blood sugar level of 500 mg% or higher. Pre-irrad. injection of insulin prevents the deaths associated with hyperglycemia. In the period of 1 to 3 days, 15% or more may have terminal respiratory paralysis due to low-calcium tetany. Periodic treatment with $CaCl_2$ is generally effective. From 12 hr and through several days the principal cause of death is a toxic uremia. Anuria frequently develops at the time of irrad. A water diuresis established by the early feeding of dilute cabbage juice generally prevents the anuria and death unless the roentgen dose is very high. Surviving animals, assisted with daily feeding of juice if anoretic, may die after 9 days owing to persistent gastric retention and/or peptic ulcers. Daily oral doses of $MgSO_4$ and $Mg(OH)_2$ reduce the incidence of these troubles. By using all the above therpay measures, the $LD_{50(30)}$ for mature rabbits has been raised from 870 r to a level of 1200 r.

2. Parenteral administration

See also nos. 115, 151, 323

BACQ, Z. M., P. FISCHER, A. HERVE, C. LIEBECQ, & S. LIEBECQ-HUTTER. Sodium fluoroacetate as a protecting agent against irradiation. Nature. 182:175-76, 1958. 274.

Injection of Na fluoroacetate, 4-5 mg per kg, 2 to 5 hr before X-irrad. (750-775 r) reduced mortality of mice from 94% at 21 days to 40%. The compound is transformed into fluorocitrate, a competitive inhibitor for aconitase.

BACQ, Z. M., A. HERVE, & P. FISCHER. X-rays and chelation agents. Bull. Acad. R. Med. Belg. s. 6, 18:226-35, 1953. 275.

Different chelation agents and substances that combine with heavy metals (diethyldithio carbamate, trihydroxy-N-methylindole) have a radio-protective effect in the mouse. The importance of copper in radio-chemical reactions is discussed. The best radio-protector in mammals, (beta-mercaptoethylamine) mobilizes the hepatic glycogen, this reaction however, seems neither related to the blocking of copper nor to the radio-protection.

BACQ, Z. M., S. LIEBECQ-HUTTER, & C. LIEBECQ. Protection against irradiation afforded by sodium fluoroacetate. Radiation Res. 13:286-97, 1960. 276.

Sodium fluoroacetate injected into mice at a dose of 4 to 5 mg/kg, 5 hr before irrad., reduced the mortality produced by 650 to 675 r w.b. X-irrad. The high levels of citric acid in the tissues of the poisoned animals returned to normal within 24 hr if 675 r X-irrad. were given 5 hr after 5 mg/kg of sodium fluoroacetate, whereas 48 hr was required in the case of non-irrad. control mice. The injection of sodium fluoroacetate produced a prolonged hypothermia. It is suggested that the fluoroacetate-induced accumulation of citrate protects the animals by complexing magnesium ions necessary for DNase activity. Animals were fed a diet containing 25-27% protein, 5-6% lipid, 60-65% carbohydrate, and 5-6% ash. They were not fasted.

BLOUNT, H. C. Effect of magnesium on the response of mice to large doses of whole body irradiation. Radiology 65:250-52, 1955. 277.

I.p. injection of 5, 10, and 15 mg of $MgSO_4$ in 1 cc of water, 5$\pm$2 min prior to exposure of mice to a LD_{74} of X-rays produced a statistically significant reduction in mortality at the 15 mg level. This was attributed, in part to a fall in body temperature and a reduced metabolic rate.

BURNETT, W. T., JR., A. W. BURKE, & A. C. UPTON. The effect of acetyl-B-methylcholine, carbamylcholine, and atropine on the survival of X-irradiated mice. AECU-1793, 1952. 278.

Administration of 0.3 ml physiological saline or 12 mg/kg of sodium bromide to male mice failed to alter $LD_{50/28}$ dose of X-irrad.

COLE, L. J., V. P. BOND, &. M. C. FISHLER. Preprotection of mice against X-ray irradiation mortality by sodium nitrite. Science 115:644-46, 1952. 279.

I.p. administration of 1.25 or 2.5 mg $NaNO_2$ ½ hr before irrad. significantly reduced the mortality of mice subjected to a single exposure of 600 or 750 r $NaNO_2$ may function as an accelerator of the decomposition of the H_2O_2 - catalase complex.

DONNELLY, C. L., C. J. ROSS, W. H. MERONEY, & R. L. HOLMAN. Studies on heavy metal poisoning. ii. Sodium citrate therapy effective 67 hours after uranium injury. Proc. Soc. Exp. Biol. Med. 57:75-78, 1944. 280.

19 of 20 adult dogs survived a lethal dose of uranium nitrate (5 mg/kg) when large doses of Na citrate (0.23 g/kg/day for 10 days) were injected i.v. The citrate injections were as effective when started as late as 67 hr after the heavy metal as when started immediately. Objections are raised to the currently accepted view that maintenance of the alkali reserve is the mechanism whereby protection is afforded, and the suggestion is offered that Na citrate supplies ions or molecules that keep the citric acid cycle of carbohydrate metabolism going while recovery takes place.

ELLINGER, F. Studies on irradiated animals. iii. Effect of saline on radiation induced mortality and weight changes. Proc. Soc. Exp. Biol. Med. 81:486-89, 1952. 281.

Intramuscular and i.p. administration of 0.9% NaCl 6 and 14 days after 410 or 385 r X-irrad. delayed mortality and improved weight in mice.

HOLLO, Z. M. & S. Z. ZLATAROV. The prevention of X-ray death by selenium salts given after irradiation. Naturwissenschafter 47: 328, 1960. 282.

Survival of rats was increased when given 0.1% selenium salt solution (subcutaneously 0.8 ml) in doses of 4.2 to 5 mg/kg after 800 r w.b. X-irrad. Pure selenium and solutions that were sterilized an excessively long time had no effect.

LAMBERT, G., J. R. MAISIN, M. MANDART, F. MEERSSEMAN, F. PODIO, & E. PLUYGERS. Influence of certain metallic ions on survival of rats receiving a lethal dose of X-rays. Compt. Rend. Soc. Biol. Paris, 114:444-48, 1950. 283.

Injection of non-toxic doses of $BaCl_2$ or Li lactate shortened the survival periods. Small doses of $HgCl_2$ prolonged the survival period and decreased the mortality percentage.

MAISIN, J. R. & G. LAMBERT. Biological interferences between X-rays and certain radioisotopes. J. Belg. Radiol. 35:329, 1952. 284.

Small doses of Na^{24} and Co^{60} injected into rats prior to 500 r X-irrad. improved survival curves.

PETERSEN, D. F. & P. D. WARDEAN. Pharmacological and toxicological compounds as protectiveor therapeutic agents against radiation injury in experimental animals. ii. Effects of metallic ions on radiation lethality. USAF Radiation Lab. Rpt. no. 22:87-99, 1957. 285.

Mice were fed a basal diet of Rockland mouse chow and tap water. Test materials were injected daily following 800 r w.b. X-irrad. Sodium fluoride, 15 mg/kg increased mean survival time from 8.4 to 10.7 days. No significant effects were seen from calcium gluconate or lactate, magnesium chloride or sulfate, or cobalt chloride. Mean survival times was reduced by manganese citrate and chloride, zinc sulfate and sodium fluoride (25 mg/kg).

C. TISSUE LEVELS AND EXCRETION

See also nos. 99, 102, 105, 257, 258, 270, 273.

ADLER, K. & M. ADLER. Effect of X-irradiation on blood sodium. Strahlentherapie 42:584-90, 1931. 286.

In rabbits blood sodium decreases by 6.54 to 15.24% after 1000 r; in patients receiving normal doses of X-ray therapy no reduction in blood sodium could be found.

ANDREWS, H. L. & K. C. BRACE. Terminal phenomena associated with massive doses of X-rays. Am. J. Physiol. 175:138-40, 1953. 287.

Guinea pigs were exposed to 25,000 r whole or partial body X-irrad. (max. survival appears to have been ca 40 hr, but this statistic is not given.) Blood studies (no time interval stated) revealed normal hematocrit, serum Na, Ca, and K, cholesterol and uric acid. NPN was elevated and blood sugar reduced. Cardiac and CNS changes are described.

BABENKO, G. A. Changes in the quantity of cobalt in the blood and organs of dogs in radiation sickness. Ukr. Biokhim. Zh. 32:93-99, 1960. 288.

Co content of blood increases in acute radiation sickness; in the chronic form the changes were wave-like in nature. At death Co content of liver, spleen, lungs, and muscles was decreased while kidney content was higher.

BAKER, D. G. & E. A. SELLERS. Electrolyte metabolism in the rat exposed to ionizing radiation. Canad. J. Biochem. Physiol. 34:835-43, 1956. 289.

Rats were subjected to single lethal dosesof X-irrad. or prolonged exposure to gamma radiation (60 r/24 hr). Blood electrolytes were essentially constant. Balance studies showed small losses of Na, K, and Cl during the first few days of chronic exposure. Thereafter, Na and Cl were nearly in balance but K continued to be lost.

BENNETT, L. R., V. C. BENNETT, & J. W. HOWLAND. Effect of acute X-radiation on distribution and excretion of radiosodium in the rat. (Abstr.) Fed. Proc. 8:350, 1949. 290.

In rats during first 4 days following mid-lethal irrad. there was a marked retention of radiosodium with shifts into intestinal tract, kidney, spleen, and liver and increased serum levels. Urinary Na excretion was reduced.

BOWERS, J. Z., V. DAVENPORT, N. CHRISTENSEN, & C. J. GOODNER. Effects of acute whole-body X-irradiation on salt and water metabolism and their clinical significance. Radiology 61:97-102, 1953. 291.

Acute w.b. irrad. at an LD_{50} level in rats is associated with a loss of K and gains in Na and Cl in radiosensitive tissue. Radioresponsive tissue and radioresistant tissue do not show comparable changes. The balances between the intake of K, Na, and Cl in the food and the loss of these elements in the urine and feces is not different in irrad. rats from that in pair-fed control rats.

BOWERS, J. Z. & K. G. SCOTT. Distribution and excretion of electrolytes after acute whole-body irradiation injury. i. Studies with radiopotassium. Proc. Soc. Exp. Biol. Med. 78:645-48, 1951. 292.

Rats given ca 800-900 r irrad. showed substantial losses of tissue K, increased urinary excretion and increased fecal levels with the onset of diarrhea.

BOWERS, J. Z. & K. G. SCOTT. Distribution and excretion of electrolytes after acute whole-body radiation injury. ii. Studies with radiosodium. Proc. Soc. Exp. Biol. Med. 78:648-52, 1951. 293.

Rats given 710 or 880 r X-irrad. show decreased excretion of Na in the urine and increased fecal levels. Tissue changes are recorded.

CASTER, W. O. & W. D. ARMSTRONG. Electrolyte balances following total body X-irradiation. Proc. Soc. Exp. Biol. Med. 90:56-57, 1955.294.

Electrolytes were provided by diet (ad lib.) and i. p. injection. Results indicate a prompt loss of Na and K after 700 r w.b. X-irrad., a delayed loss and recovery beginning at days 8-10 of Cl.

CASTER, W. O. &. W. D. ARMSTRONG. Electrolyte metabolism after total-body X-irradiation. Radiation Res. 5:189-204, 1956. 295.

Changes in Cl, Na, K, and DNA of rat tissues 3 hr to 10 days after 700 r w.b. X-irrad. are described.

CHANUTIN, A. & S. LUDEWIG. Effect of whole body X-irradiation on serum iron concentration of rats. Am. J. Physiol. 166:380-83, 1951. 296.

Rats were exposed to 100 to 1500 r X-irrad. Serum Fe concentration rose the 1st day following doses of 100 r or higher and remained elevated for about a week in 500 and 600 r groups.

EDELMANN, A. Effects of X-radiation on water and electrolyte metabolism in the rat. (Abstr.) Fed. Proc. 8:39, 1949. AECU 201, 1948. 297.

Urinary excretion of Na, K, and Cl increased during 1st and 5th 24-hr period; polydipsia and polyuria occurred at the same periods.

FULTON, G. P. & F. N. SUDACK. Effect of total body X-irradiation on serum electrolyte levels and electrocardiograms of the golden hamster. Am. J. Physiol. 179:135-38, 1954. 298.

Hamsters irrad. with 600 r showed no changes in factors studied. Serum K rose and Na fell following 1000 r irrad. Bradycardia, electrocardiographic changes and severe vasoconstriction were also seen.

GLENN, J. L. & W. R. BOSS. Effect of whole-body irradiation on excretion of sodium and potassium in the rat. (Abstr.) Fed. Proc. 15:75-76, 1956. 299.

No changes were seen in serum or urinary Na levels between rats given 500 or 1000 r w.b. X-irrad. and their pair-fed controls during 96 hr after exposure. Urinary and serum K were significantly elevated.

GOODMAN, R. D. & M. VOGEL. Effect of X-irradiation on serum potassium and sodium levels in rabbits. Am. J. Physiol. 175:29-32, 1953. 300.

No relationship between radiation shock or sickness and concentration of serum Na or K was seen in rabbits given 600-800 r acute w.b. X-irrad. High serum K was noted terminally in some cases.

HEGGEN, G. E., K. B. OLSON, C. F. EDWARDS, L. B. CLARK, & M. MAISEL. Effects of X-irradiation on trace element levels in rat tissues. Radiation Res. 9:285-90, 1958. 301.

14 trace elements were studied in liver, spleen, kidneys, and lungs of rats, 2, 4, 6, 8, and 12 days after 600 r w.b. X-irrad. Data are given for only Fe, Zn, Cu, and Mn. Largest changes occurred in spleen where Fe and Mn concentration and total content rose and Zn and Cu increased in concentration but decreased in total content.

JACKSON, K. L., R. RHODES, & C. ENTENMAN. Electrolyte excretion in the rat after severe intestinal damage by X-irradiation. Radiation Res. 8:361-73, 1958. 302.

Both Na and K excretions are increased after 1500 r w.b. X-irrad. K was lost in urine, Na by way of the gastrointestinal tract. Total K loss was 27% greater than in controls; Na loss was 138% greater, amounted to 1.50 mg and was sufficient to cause death.

KROETZ, C. H. The significance of physio-chemical and chemical changes in blood composition in radiation effects. Strahlentherapie 18: 545-54, 1924. 303.

pH and water and electrolyte physiology of the blood were investigated. It was concluded that intramolecular changes in the proteins are the primary effects of radiation on the organism; loss of CO_2, hypocapnia, hypochloremia, alkalosis are secondary effects.

LUDEWIG, S. & A. CHANUTIN. Effect of whole-body X-irradiation on the storage of iron in liver, spleen, and kidney of rats. Am. J. Physiol. 166:384-86, 1951. 304.

Fe content of liver and spleen increased steadily for the first 2 week after 500 r X-irrad., and decreased during the 3d week. Small increases were noted in kidneys during 2d week.

LUSHBAUGH, C. C., D. B. HALE, & T. T. TRUJILLO. Additional observations on electrolyte and water loss in radiation damage: Potassium^{42} and HTO. LAMS-2445: 394-99, 1959. 305.

K and water loss were studied in normal, starved, and irrad. rats. K^{42} and HTO were used as tracers. Results indicate that K is conserved in the starving irrad. rat and that any water loss is proportional to loss of protoplasm.

LUSHBAUGH, C. C., J. SUTTON, & C. R. RICHMOND. The question of electrolyte loss in the intestinal death syndrome of radiation damage. Radiation Res. 13:814-24,1960. LAMS-2445: 384-93, 1959. 306.

Results are reported from an investigation of the effects of acute doses of w.b. irrad. on the distribution and excretion of body Na. Data are included from studies of Na^{22} distribution and retention in irrad. rats. A comparison of gross retention rates of Na^{22} in fasted control and irrad. animals failed to support the idea that increased Na loss is either caused by radiation or plays a dominant role in the intestinal death syndrome of massive acute radiation exposure.

McDONALD, R. E., R. E. JENSEN, E. ROSS, H. C. URRY, & P. B. PRICE. A study of the irradiation syndrome. ii. Tissue water and tissue electrolytes. Amer. J. Roentgenol. Rad. Ther. & Nuclear Med. 74:889-97, 1955. 307.

The only important change seen in tissues of dogs following w.b. irrad. was decreased K and increased Na and Cl concentration in lymph glands.

SOBERMAN, R. J., R. P. KEATING, & R. D. MAXWELL. Effects of acute whole-body X-irradiation upon water and electrolyte balance. Am. J. Physiol. 164:450-56, 1951. 308.

Dogs given 450 to 500 r irrad. showed increased plasma volume, decreased red-cell volume and no change in plasma electrolytes.

TOOSY, M. H. Role of calcium in radiation injury. 2d United Nations Conference on the Peaceful Uses of Atomic Energy, 22:544-47, 1958. 309.

The relationship of irrad., endocrines, and Ca metabolism is discussed with reference to skin.

TRUM, B. F., T. J. HALEY, M. BASSIN, J. HEGLIN, & J. H. RUST. Effect of 400 fractional whole body gamma-irradiation in the burro (Equus asinus asinus). Am. J. Physiol. 174:57-60, 1953. 310.

Radiation syndrome is described, including the observation that plasma Fe rose following the first 400 r irrad. and continued to be elevated until exitus. (N.B. There are several other papers from this group detailing hyperferremia in the burro at various doses of radiation.)

VIII. V I T A M I N S, G E N E R A L

A. CLINICAL STUDIES

See also no. 245.

BEAN, W. B., T. D. SPIES, & R. W. VILTER. Note on irradiation sickness. Am. J. Med. Sci. 208:46-54, 1944. 311.

Normal persons were given 400 r X-irrad. to the left side of upper abdomen. Tests for codehydrogenase, biotin, riboflavin, pantothenic acid, and nicotinic acid content of the blood were made before and 6 and after 24 hr treatment. In some cases pyruvate and glutathione were determined. Patients on a diet low in vit. B complex developed radiation sickness which could be prevented or ameliorated by giving nicotinic acid or thiamine a few days in advance. Optimum time for vit. therapy is before and not after the syndromeof radiation sickness appears.

HERVE, A. Considerations of radiation sickness and its therapy. Bruxelles Med. 29:445-50, 1949. 312.

Observations of 210 cases receiving radiation delivered at 151 to 200 kv show that 34.4% and 16.9% developed radiation symptoms at low and high tensions, respectively. The author concludes that higher voltages are better tolerated for the same dose than the lower voltages, but that other physical factors and specific radiation sensitivity must be also taken into consideration. Vit. B complex therapy gave good or favorable results in 46 out of 62 cases, showing an initial remission of gastrointestinal symptoms.

HUGENIN, R., J. FAUVET, & J. PONTHIEU. Prophylaxis and treatment of radiomucites. Bull. Mem. Soc. Med. Paris 64:983-85, 1948. 313.

Pantothenic acid, nicotinic acid, and nicotinamide were not effective in radiomucites in patients undergoing radium therapy for bronchopulmonary tumors.

MONTAG, C. Treatment of roentgen sickness with Avil and vitamins. Therapie der Gegenwart 4:148-49, 1952. 314.

Clinical use in 250 patients of Avil, a proprietary antihistamine, in the form of 25 mg tablets 3 or 4 times daily, and of large injections of vit. C, B_1, B_6, B_{12}, and nicotinic acid mixtures in the treatment of radiation sickness is related. Good results are said to have been obtained, although data are not given.

WALLACE, W. S. Studies in radiation sickness. ii. Vitamins B_1 and C and small intestinal change in radiation sickness. Southern Med. J. 34: 170-73, 1941. 315.

Large parenteral doses of vit. B_1 and C, administered concurrently with radiation eliminates almost entirely nausea and vomiting. The occurrence or severity of diarrhea or radiation sickness are not diminished, nor the characteristic ideal changes seen after heavy pelvic irrad.

B. LABORATORY STUDIES

See also nos. 78, 126, 151, 252, 381, 488, 489, 490, 493, 506, 512.

BUBLITZ, H. Effect of vitamin B complex administration on radiation leucopenia. Zbl. Ges. Radiol. 32:468, 1941, Abstr. of dissertation. 316.

Philocytin (made from brewers yeast and containing the entire B complex) was given i.p. to rabbits after X-irrad. Leukocytes reached pre-irrad. levels after 10 days as compared to controls that reached lowest leukocyte level on the 12th day. With pre-irrad. injection normal leukocyte level was reached on the 6th day. Animals that had received Philocytin without irrad. had increased leukocyte counts up to 4 weeks. Animals that had received vit. B free diet previous to irrad. showed the same increase in leukocytes after irrad. if treated with B complex injection. The diet alone produced an initial increase in leukocytes which has not been explained.

DZYUBKO, N. YA. The effect of a number of B vitamins on acute experimental radiation sickness. Vrach. delo. 3:253-56, 1957. 317.

Beginning with the day of 1000 r X-irrad., rats (200-250 gm) were given subcutaneously in mg/kg of body weight: 0.83 thiamine, 0.08 riboflavin, 0.166 pyridoxine, 0.66 niacin; or 0.25 mcg of vit. B_{12}/kg; or by mouth 100 mg of para-aminobenzoic (paba) acid. Survival time was increased from 4.52 days in controls to: thiamine, 6.2; paba, 6.4; B_{12}, 6.5; riboflavin, 7.35; B_6, 7.4; and niacin, 7.8. No significant differences in weight losses were seen. Pyridoxine and niacin decreased leukopenia and minimized drop in O_2 consumption. Data on the latter points are not given.

JOHNSON, C. G., C. F. VILTER, & T. D. SPIES. Irradiation sickness in rats. Am. J. Roentgenol. Radium Therapy 56:631-39, 1946. 318.

Young rats fed a vit-free diet were more susceptible to radiation injury than rats on a normal diet (single w.b. dose X-ray in LD_{50} range). Peroral supplementation began 3 days before irrad. with thiamine, pyridoxine, inositol, riboflavin, nicotinamide, Ca pantothenate, and choline greatly decreased lethality.

LANGENDORFF, H., R. KOCH, & U. HAGEN. Investigations on biological radiation protection. xiii. Effect of energy rich phosphate and phosphatized vitamins on radiosensitivity of rat and mouse. Strahlentherapie 99:375-82, 1956. 319.

Administration was i. p. before irrad. Adenosine, AMP, Synkavit (vit. K), thiamine monophosphate and pyridoxal-5-phosphate had no effect. ATP is protective to rats and mice, depending on dose. Thiamine-diphosphate cocarboxylase and lactoflavin-5-phosphate sensitize rats if applied before irradiation.

LIBERMAN, A. N. The effect of vitamin B-complex on the resistance of an organism to radiation effects. Fiziol. Zh. S. S. S. R. 4: 814-20, 1958. 320.

A series of tests conducted on cats and mice in an attempt to study the prophylactic and therapeutic effects of vit. B-complex on radiation sickness demonstrated the following: 1). The therapeutic use of vit. B-complex (B_1, B_2, B_6, B_{12}, PP, folic acid, and P-aminobenzoic acid) has a favorable effect on the course of radiation sickness, increases the survival rate, decreases loss of body weight, and aids in the oxidation-reduction processes in the cellular respiration of a number of vitally important organs; 2). On the contrary, the combined use of a preliminary injection of vit. B-complex and its therapeutic use during radiation sickness causes a more severe course of radiation sickness, decreases the survival rate, increases loss of body weight, and impairs the oxidation-reduction processes in a number of vitally important organs; 3). The combined preliminary and therapeutic use of vit. B_{12} alone produces positive shifts in oxidation-reduction processes in a number of organs, but these shifts are less pronounced than those resulting from the therapeutic use of vit. B-complex.

MICHAELSON, S. M., J. W. HOWLAND, J. M. KOSZALKA, D. J. DeBOTTIS, & A. KONNERTH. The use of vitamin-fortified antibiotics in the therapy of the acute radiation syndrome in dogs. UR-434, 1956. 321.

The supplementation of a broad spectrum antibiotic with vit. and other nutritional factors was found to enhance the increase in survival of the irrad. dogs (594 r, X) over that obtained from the use of the antibiotic therapy alone. The nutritional supplement ("Perihemin": ferrous sulfate, 192 mg; vit. B_{12}, 10 mcg; ascorbic acid, 50 mg; folic acid, 0.85 mg; powdered stomach, 200 mg; insol liver fraction, 50 mg; intrinsic factor, 0.5 mg per day given 7-21 days after irrad., perorally) was ineffective when given alone.

SCOTT, G. M. The effect of extra vitamin B feeding on rats exposed to weak gamma-radiation. Brit. J. Radiol. 19:329-32, 1946. 322.

The effects of 60 r gamma-radiation/wk for 4 months to 264 young rats were lessened by addition of extra vit. B complex to the food, beginning 11 days before irrad. to the end of the experiment. Their weight increased at normal rate, coats kept in good condition, effects of radiation on reproduction were mitigated to some extent.

SIMMONS, E. L., L. O. JACOBSON, N. PEARLMAN, & C. L. PROSSER. The effectiveness of drugs in preventing or alleviating X-ray damage. In: Biological Effects of External X- and Gamma-Radiation. R. E. Zirkle, ed. Part 1, Chap. 21 New York. McGraw, 1954. MDDC-1277, CH-3329, 1946. 323.

Ascorbic acid (methyl glucamine ascorbate, Abbott "Cenolate-G") treatment of rabbits, 50 mg/day i.p. 13 days after 600 r, improved rate of recovery of leukocyte count. Rabbits given 50 mg/day i.p. 7 days before and after 600 r showed same but more marked benefit, but delayed recovery of body weight. Mice showed no protection when given i.p. on day of irrad. or after 450-600 r. Administration for one week before improved survival. Greater benefit was seen from the combined administration of ascorbic acid and 10% NaCl. Thiamine (B_1), riboflavin (B_2), and pyridoxine (B_6) were given to mice, 7 days before and after single w.b. exposure of 700 r X-rays as i.p. injections in 1 ml Ringer solution (dosages: 1.0 and 2.0 mg B_1; 0.2 and 0.5 mg B_2; 0.1 mg B_6). These vit. had no effect on survival, survival time, or body weight. Same lack of benefit was seen when radiation was accumulated at 100 r/day. Nicotinamide (NA) and diphosphopyridine nucleatide (DPN) were also tested. Na given before irrad. prolonged survival after single w.b. X-irrad. in mice. 2 mg i.p. was more beneficial than 1, 4, or 8 mg. After irrad. NA may be toxic. When irrad. was accumulated in 50 r/day increments, the LD_{50} dose for Ringer-injection was 735 r and for NA (2 mg in 0.1 ml Ringer, i.p.), 1160 r. At 100 r/day LD_{50}, was 1140 r for Ringer, 1240 r for NA and 1310 r for DPN. There was no differences in weight loss. NA increased heterophil count recovery in both mice and rabbits but did not influence survival of rabbits following a 600 r w.b. dose.

C. TISSUE LEVELS AND EXCRETION

See also no. 311.

BARBIERI, L. L., G. MARZOCCHI, G. RUMPIANESI, M. A. BRUNELLI. Excretion of thiamine, riboflavin, nicotinic acid, ascorbic acid, and 17-keto steroids in the urine after irradiation of the thyroid with X-rays. Intern. Z. Vitaminforsch. 25:261-74, 1954. 324.

After irrad. of the thyroid with X-rays, the urinary excretion of thiamine, ascorbic acid, and 17-keto steroids is increased; that of riboflavin and nicotinic acid is decreased.

DUTRA DE OLIVEIRA, J. E., W. N. PEARSON, K. P. MISRA, G. W. HUDSON, & W. J. DARBY. The effects of X-irradiation on the vitamin excretion of the rhesus monkey (Macaca mulatta). J. Nutrition 59:527-37, 1956. 325.

Monkeys fed a complete purified diet were exposed to 325 r (N=2), 400 r (N=2) or 650 r (N=3) of X-irrad. Controls were pair-fed. Decreases in urinary excretion of riboflavin, thiamine and N^1-methylnicotinamide were observed which were attributable to decreased food intake. A temporary moderately increased excretion of vit. B_6 and pteroyl-glutamic acid occurred as a consequence of irrad. Excretion of diketogulonic acid increased but there were no significant changes in blood ascorbic acid.

MARZOCCHI, F. & L. L. BARBIERI. Roentgen stimulation of the diencephalic-hypophyseal system and the urinary excretion of thiamine and riboflavin. Acta Vitam. 5:113-17, 1951. 326.

Irrad. of the pituitary in man did not alter urinary excretions.

MORCZEK, A. Effect of ionizing radiation on ability of serum proteins to bind vitamins. Strahlentherapie 105:138-42, 1958. 327.

Freshly withdrawn serum was exposed to X-ray doses of 50-500 Kr. The change in contents of free biotin, riboflavin, and niacin in the irrad. serum was then microbiologically examined. Contents of free biotin was 240 mg/100 mg in normal serum. 25 Kr irrad. caused increase of 20% in biotin and biotin contents increased with larger doses of 150 Kr; there was a temporary decrease with a dose of 250 Kr, and 300 Kr affected renewed freeing of biotin to a maximum of 416 mg/100 ml; 500 Kr again led to decline. Riboflavin and niacin showed comparable curves.

PEARSON, W. N., J. P. OWENS, G. W. HUDSON, & W. J. DARBY. Effect of whole-body X-irradiation on urinary B-vitamin excretion of rats. Am. J. Physiol. 173:120-24, 1953. 328.

Rats given 500 r (incl. backscatter) of w.b. X-irrad. show increased urinary excretions of riboflavin (B_2), niacin (N), folic acid (FA), and vit. B_6. Increase in B_2 is partially due to anorexia; N and FA are irrad. effects. In the case of B_6 irrad. rats excrete less than do pair-fed controls although both are elevated above preceding values.

IX. THIAMINE (VITAMIN B_1)

A. CLINICAL STUDIES

See also nos. 311, 314, 315.

IMLER, A. E. & H. WAMMOCK. Vitamin B_1 in irradiation sickness. Am. J. Roentgenol. Radium Therap. 43:243-48, 1940. 329.

Large doses of B_1 were given subcutaneously or orally to 21 patients with radiation sickness following therapy. Subcutaneous injection of 3000 i.u. gave complete relief in most cases. Symptoms were relieved within 24 to 48 hr by oral route, one to three hr with subcutaneous.

MARTIN, C. L. & W. H. MOURSUND. Irradiation sickness. Radiology 30: 277-84, 1938. 330.

Barbiturates and i.v. saline and glucose solutions have a definite palliative effect on irrad. sickness. Vit. B_1 given in large doses (2000 i.u. daily for at least 2 days before treatment begins) often prevents all the symptoms and seems to have a more specific effect.

WHITMORE, W. H. The prevention of irradiation sickness; use of B_1 in roentgen therapy. Am. J. Roentgenol. Radium Therap. 49:83-98, 1946. 331.

Radiation sickness in patients undergoing therapy was usually prevented by daily doses of 6-9 mg of thiamine chloride.

B. LABORATORY STUDIES

See also nos. 185, 317, 318, 319, 320, 323, 488, 489.

GRAEVSKAIA, B. M. R., R. IA. KEILINA, & S. E. MANOILOV. The effects of aneurin (vitamin B_1) on the glycogenic function of the liver of rats subjected to total irradiation with different doses of roentgen rays. Vestn. Roentgenol. Radiol. 28: no.6, 22-25, 1953. 332.

Rats on a carbohydrate diet were subjected to 500, 1000, and 2000 r X-irrad. and killed 2, 4, and 8 days later. Irrad. with 500 r lowered liver glycogen on the 2d day from 1670 mg% to 377 mg%. At 1000 and 2000 r the shifts were pronounced at the 4th day. Subcutaneous administration of 6 mg of B_1 per rat prior to 500 r irrad. prevented the changes in glycogen but no benefit was seen at 1000 and 2000 r.

LESHCHINSKII, A. F. & A. N. BORISENKO. Effect of vitamin B_1 on the organism of animals subjected to the action of ionizing radiation. Farmakol. Toksikol 23: no.2, 169-73, 1960. (OTS JPRS-5327.) 333.

A study was made of the effects of pharmacologically active doses of vit. B_1 on w.b. X-irrad. animals over a period of 1 to 1½ months. Guinea pigs, rabbits, and white mice were exposed to doses of 100, 725, and 500 r respectively. It was found that vit. B_1 did not exert a desensitizing effect on anaphylactized previously-irrad. animals. A separate administration of vit. B_1 and X-rays inhibited development of anaphylactic shock. Administration of thiamine bromide to irrad. animals aggravated the general condition and led to higher death rates, reduction of cholinesterase activity in the blood, increased leukopenia, and changes in the "elucocytary formula."

C. TISSUE LEVELS AND EXCRETION

See also nos. 315, 324, 325, 326.

BERNARDINI, A. Modifications of the content of vitamins of the B complex in the tissues of irradiated animals. ii. The changes in thiamine. Boll. Soc. Ital. Biol. Sper. 31:295-97, 1955. 334.

X-irrad. caused a dose-dependent decrease in both free thiamine and cocarboxylase content of rat tissues.

DUNLAP, C. E. & F. C. ROBBINS. Effect of roentgen rays, radon and radioactive phosphorus on thiamine chloride. Am. J. Roentgenol. 50:641-47, 1943. 335.

Thiamine content of mouse blood and liver was not affected by 800 r w.b. X-irrad.

UENO, I. The effect of radiation on vitamin B_1 metabolism. Med. Radiol. 5: no. 4, 38-42, 1960. 336.

Investigations were made of the influence of radiation on the changes in the blood level of vit. B_1 and changes of vit. B_1 excretion in urine.

X. RIBOFLAVIN (VITAMIN B_2)

A. CLINICAL STUDIES: NONE

B. LABORATORY STUDIES

See also nos. 317, 318, 319, 320, 323, 368, 489.

KOCH, R. & A. BOHLANDER. Experimental investigations on vitamin effects on liver metabolism after radiation injury. ii. Effect of lactoflavin and pyridoxine on glycogen and total nitrogen of the liver in total body irradiated animals. Strahlentherapie 85:599-605, 1951. 337.

Mice were given 350 to 400 r of X-irrad. on each of 5 consecutive days. Subcutaneous injections of lactoflavin, 0.5 mg, or pyridoxine, 2.5 mg were given daily for 6 days before irrad. and after each exposure except the last. Animals were killed several hr after the last exposure. Neither irrad. nor vit. administration affected liver N. Liver glycogen content dropped to 27% of normal after irrad.; lactoflavin treatment increased the loss (55%) and pyridoxine decreased it (51%) as compared with untreated.

KOCH, R. & G.v. EHRENSTEIN. Do radiation sensitization properties belong to 3,4-benzpyrene or lactoflavin-5-phosphate? Strahlentherapie 110:41-52, 1959. 338.

Prior administration of lactoflavin-5-phosphate does not change sensitivity to w.b. X-irrad. in rats.

PAREKH, C. & S. O. BROWN. Effects of chronic irradiation in the survival of vitamin deficient Swiss albino mice. In: The influence of dietary deficiencies on the survival of albino rats and mice subjected to continuous low intensity radiation. DA-007-49-MD-957, 1960. 339.

Duplicate series of 12 mice (20 g) were Co^{60}-irrad. at 2, 5, or 10 r/day until there were no survivors. Mortality from irrad. did not differ significantly from that due to deficiency of pantothenic acid or pyridoxine. In one series riboflavin-deficiency appeared to increase sensitivity to radiation but there were no significant differences upon replication. Over 28-weeks differences in mortality due to radiation dose were not seen in groups fed either a complete synthetic diet or Purina. Basal diets were fat-free but contained 2 dr methyl linoleate per 100 g.

C. TISSUE LEVELS AND EXCRETION

See also nos. 311, 324, 325, 326, 327, 328, 351, 417.

BERNARDINI, A. & A. LINO. Modification of the vitamin B content of the tissues of irradiated animals. i. The modification of riboflavin. Boll. Soc. Ital. Biol. Sper. 31:297-99, 1955. 340.

X-irrad. of the head of the rat decreased riboflavin content of brain and to a smaller extent in other organs. Irrad. of abdomen or thorax caused greater losses in liver and muscles but less in brain.

YOUNG, N. F. & G. Z. WILLIAMS. The effects of irradiation on azo dye neoplasia in the rat liver. ii. Catalase, alkaline phosphatase, arginase, and riboflavin levels of the liver following X-ray and radiogold irradiation of rats fed dimethylaminoazobenzene. (Abstr.) Cancer Res. 11:291, 1951. 341.

Rats were maintained for 24 weeks on a synthetic diet containing 0.04% m'-methyl-dimethylaminoazobenzene. Groups were treated with (a) 250 r X-irrad. 3 times weekly to 3600 r, (b) intrasplenic injections of 2.0 mc or 0.6 mc radioactive gold colloid, and (c) combination of 1600 r X-irrad. and 2.0 mc of intrasplenic radioactive gold colloid (total of 168 animals). Levels of alkaline phosphatase, catalase, arginase, and riboflavin were determined on homogenates of liver tissue. Catalase was low during periods on the riboflavin-deficient diet but rose to normal levels after the animals were returned to stock diet. Irrad. produced no significant changes, and the levels were generally higher in the livers containing tumors. The riboflavin content of the livers was low (10-12 μg per g) with basal riboflavin deficient diet and azo dye, and returned to normal levels of 20 to 30 μg on stock diet. The majority of livers of irrad. and tumor-bearing animals contained less riboflavin than normal-appearing livers without irrad. Irrad. produced no changes in arginase levels. It was concluded that ultimate dietary changes in catalase and riboflavin levels are not influenced by irrad.

XI. N I A C I N
(N I C O T I N I C A C I D, N I A C I N A M I D E,
V I T A M I N PP)

A. CLINICAL STUDIES

See also nos. 311, 313, 314, 343.

BEAN, W. B., R. W. VILTER, & T. D. SPIES. The effect of Röntgen rays on the blood codehydrogenases I and II. Ann. Internal. Med. 13: 783-86, 1939. 342.

X-radiation was administered to 3 healthy persons, 2 cases of myelogenous leukemia and 3 pellagrins in remission. Blood codehydrogenase I and II levels fell 60-90% within 12 hr and a pigment similar to that seen in pellagra developed. These changes disappeared in 48 hr. Administration of nicotinic acid prior to irrad. prevented the pigment development but not the enzyme changes.

DOMSHLAK, M. P., et al. Complications during radiation therapy and their treatment. Trudy Vsesoyuz. Konf. Med. Radiol., Moscow (Proc. Conf. Med. Radiology. Clinical aspects and therapy of Radiation Sickness). p.170-74, 1957. 343.

Nicotinic acid (0.02 g dose 3-4 times daily) ameliorated the more severe symptoms of radiation sickness such as nausea and vomiting. Caffeine (0.1 g 2 times daily) prevented leukopenia. A mixture of the methyl esters of linolenic and linoleic acids and amino acids promoted epithelization of injured skin in 2-9 days, compared to 9-25 days in controls.

GRAHAM, J. W. Radiation sickness. J. Amer. Med. Assn. 113:664-67, 1939. 344.

Results from nicotinic acid therapy appear to be better than from pentobarbital sodium or intramuscular liver. No relation to porphyrin metabolism could be shown. Abnormal excretion of porphyrin is related to a disturbance of hematopoietic activity or of liver function.

GRIGORJEV, IU. G. Some data on the application of nicotinic acid in the treatment of complications of radiation therapy. Med. Radiol 1: no. 4, 67-70, 1956. 345.

Patients undergoing radiotherapy (total 1000-9000 r, at 150-350 r/treatment, local; 150-200 r, at 25-50 r per general treatment with X-ray or Co^{60}) were given 0.02 g nicotinic acid perorally 3-4 times per day. In 13, NA was given prophylactically (I); in 12 during the "general reaction" (II); in 22 at different later times for arresting leukopenia (III). Treatment was not effective in I and III. Beneficial effect in terms of leukopenia and nausea in II.

HUANT, E. Effect of nicotinamide on local tolerance of the skin and deep tissues to X-rays; results of increasing dose. Gaz. hopitaux (Paris) 120:313-14, 1947. 346.

Nicotinamide was administered by intramuscular injection or occasionally by mouth, average dose 40 to 60 g to 100 patients receiving radiation treatment. In 70% of cases, skin tolerance increased by 50 to 75% and doubled in 20% of cases.

LESSA, Z. T. Nicotinic acid in treatment of irradiation sickness. Rev. Paulista Med. 26:135-50, 1945. 347.

Daily dose of 25-50 mg was administered orally to 65 patients receiving radiation therapy, for prevention of "radiation sickness." More than 3/4 did not show radiation effects. A few cases of cutaneous reactions, tenesmus and diarrhea resulted from administration of nicotinic acid.

SPIES, T. D., W. B. BEAN, &. R. E. STONE. The treatment of subclinical and classical pellagra; use of nicotinic acid, nicotinic acid amide and sodium nicotinate with special reference to the vasodilator action and the effect on mental symptoms. J. Am. Med. Assn. 111:584-92, 1938. 348.

In seven cases of radiation sickness nicotinic acid was used orally in divided doses totaling from 200 to 1000 mg daily. Prompt cessation of nausea, vomiting, anorexia, and headache was noted. In 5 of the cases the abnormally large amount of porphyrine in the urine returned to normal.

B. LABORATORY STUDIES

See also nos. 151, 317, 318, 320, 323, 488, 489, 490, 491.

TEUCLO, D. Action of vitamin PP in modification of blood changes caused by X-rays. Arch. Sci. Med. (Torino) 70:271-302, 1940. 349.

Prophylactic treatment of dogs with Na and nicotinic acid before irrad. ameliorated the hepatic malfunction causing abnormal elimination of porphyrine; also the vago-sympathetic equilibrium was reinstated. Vit. PP must be administered in small doses and only at intervals of time to avoid detrimental or toxic reactions.

C. TISSUE LEVELS AND EXCRETION

See also nos. 311, 324, 325, 327, 328, 342.

BERNARDINI, A. & A. LINO. Modification of the vitamin B content of the tissues of irradiated animals. iii. The changes in nicotinic acid. Boll. Soc. Ital. Biol. Sper. 31:297-99, 1955. 350.

X-irrad. decreased the nicotinic acid content of rat liver and muscle.

JARVIS, J. L. & D. CAYER. Effect of radiation therapy on the urinary excretion of niacin and riboflavin in patients with malignant diseases. Radiology 52:574-78, 1949. 351.

Excretions were unchanged by irrad. but the patients showing most severe radiation sickness had lower excretory levels of these compounds.

KALASHNIKOVA, V. P. Changes of nicotinic acid metabolism in irradiated rats receiving different diets. Voprosy Pitania 17: no. 4, 15-19, 1958. 352.

Rats were fed a synthetic 18% protein diet alone or with a supplement of 0.5 g dry beef liver for 45 days before and 30 days after 500 r w.b. X-irrad. Urinary excretion of N'-methylnicotinamide decreased after irrad. but less so in the liver supplemented group.

KUMTA, U. S., S. U. GURANI & M. B. SAHASRABUDHE. Influence of total body X-irradiation on the levels of creatinine phosphate, inorganic phosphorus, and adenosinetriphosphate (ATP) in muscle and creatinine, creatine, N'-methylnicotinamide, and nitrogen in urine. J. Sci. Ind. Research, India 16C:179-84, 1957. 353.

After w.b. irrad. excretion of creatine and N'-methylnicotinamide in urine is increased 2-fold, while that of creatinine is increased by 160%.

VAN HEYNINGEN, R., A. PIRIE, & J. W. BOAG. Changes in lens during the formation of X-ray cataract in rabbits. Part 2. Biochem. J. 56: 372-79, 1954. 354.

During the formation of lens opacity there is progressive and almost complete loss of glutathione and of protein SH groups. It seems that coenzyme A and nicotinic acid content may diminish progressively as opacity develops in the lens, but the changes in the early stage are not striking.

XII. PYRIDOXINE (VITAMIN B_6)

A. CLINICAL STUDIES

See also no. 314.

ELLIS, F. & B. A. STOLL. Radiation sickness: a clinical investigation. J. Fac. Radiologists, London (Now, Clin. Radiol.)3:207-22, 1952. 355.

Report based upon results of treating 225 patients complaining of radiation sickness. Drug trials (296) were carried out according to a prearranged control plan. All drugs gave some relief including the inert placebo (lactose, 5g). Inert tablets gave 19-29% relief compared with 46-60% from best drug combinations which were pyridoxine HCl, 10mg and dilute hydrochloric acid, 20 minim of 7% solutions.

LAMARQUE, P., H. POURQUIER, & J. GARY-BOBO. Combination of vitamin B and methionamine in radiation protection. J. Radiol. Electrol. 40:818-20, 1959. 356.

50 patients who received 6000-7000 r telecobalt therapy were given a combination of B_6 and methionamine by mouth or i.v. (300 mg vit. B_6 and 2.5 g methionamine daily doses). Improvement from radiation sickness was noted 2-3 days after the 1st dose. Diarrhea caused by irrad. of the pelvic area was not improved.

MAXFIELD, J. R., JR., A. J. McILWAIN, & J. E. ROBERTSON. Treatment of radiation sickness with vitamin B_6 (pyridoxine hydrochloride). Radiology 41:383-88, 1943. 357.

I.v. administration of B_6 was the most effective single treatment of radiation sickness.

OPPENHEIM, A. & B. LIH. Peroral administration of vitamin B_6 (pyridoxine hydrochloride) in the treatment of radiation sickness. Radiology 47: 381-85, 1946. 358.

Administration of 75-100 mg of B_6 ½ hr before meals, 3-4 times per day, produced excellent results in 30 cases (60%); good in 12%; fair in 16%; and was ineffective in 12%. In one patient symptoms were aggravated by vit. therapy.

REEVES, R. J. Treatment of roentgen sickness with oral administration of pyridoxine hydrochloride (vitamin B_6). Southern Med. J. 39: 405-07, 1946. 359.

Daily dose of 100 mg was an effective treatment.

ROVELLO, F. & L. FERRI. Treatment of radiation leukopenia with vitamin B_6. Haematologica (Pavia) 32:319-31, 1948. 360.

Administration of 100 mg of pyridoxine daily to 10 patients prevented the leukopenia induced by radiation therapy.

SCOTT, L. D. & G. J. TARLETON. Pyridoxine hydrochloride (Vitamin B_6) in the control of radiation sickness: Preliminary report. Radiology 47:386-91, 1946. 361.

I.v. administration of 25 mg of pyridoxine prevented nausea and vomiting in patients receiving radiation therapy. Some patients obtained no relief with 25 mg but did with 50 mg.

SHORVON, L. M. Further survey of radiation sickness with particular reference to its treatment by pyridoxine. Brit. J. Radiol. 22: 49-55. 1949. 362.

Localized X-ray doses ranging from 275-720 r daily were administered to 69 cancer patients. Peroral or i.v. administration of pyridoxine HCl was said to be a reliable but not infallible treatment of radiation sickness. Treatment with B_6 improved leukocyte counts.

SHORVON, L. M. Pyridoxine in treatment of radiation sickness. Brit. J. Radiol. 19:369-70, 1946. 363.

Syndrome of radiation sickness is described, with reference to body area irradiated. Reports beneficial effect of pyridoxine administered in 22 of 24 cases, together with improved leukocyte counts.

SILVERMAN, A., M. M. KLIGERMAN, J. W. FERTIG, & K. ELLIS. A study of the effectiveness of pyridoxine and dramamine on clinical radiation sickness. Radiology 66:403-07, 1956. 364.

Neither compound influenced the frequency or duration of radiation sickness in a controlled study of 185 patients undergoing therapy.

VanHALTERN, H. I. The use of pyridoxine in radiation sickness. Radiology 47:377-80, 1946. 365.

Pyridoxine, 25-50 mg, was administered i.v. to 81 patients undergoing radiotherapy. Excellent results were noted in 54%, good in 35%, and marginal in 11%.

B. LABORATORY STUDIES

See also nos. 317, 318, 319, 320, 323, 337, 339, 376, 384, 391, 488, 489.

ANDERSON, C. T., H. BLASCHKO, J. H. BURN & R. H. MOLE. The pressor amines in the adrenal medulla after irradiation. Brit. J. Pharmacol. 6:342-50, 1951. 366.

Beginning 48 hr after lethal w.b. X-irrad. the content of pressor amines in the adrenal gland was progressively reduced. Dopa-decarboxylase activity in the liver, reduced after irrad. to some extent, was restored by adding pyridoxine to the diet, but this did not affect the fall in pressor amines.

ARTOM, C., W. E. CORNATZER, & G. T. HARRELL, JR. Protective role of pyridoxine against toxic effects of P^{32}. Proc. Soc. Exp. Biol. Med. 79:494-97, 1952. (AECU-1811, 1952). 367.

Mice were given a single injection of radioactive phosphate (5-6 μc/g). Pyridoxine administration did not influence lethality in animals on a 5% casein diet but prompted survival when deficiency was induced by administration of desoxypyridoxine or by use of a 30% casein diet with added cysteine or methionine.

BROWN, S. O. The effect of chronic gamma-radiation on avitaminotic albino rats. In: The influence of dietary deficiencies on the survival of albino rats and mice subjected to continuous low intensity radiation. DA-007-49-MD-957, 1960. 368.

Groups of 10 rats (50 g), control or irradiated at 10 r/day, were fed an adequate purified diet or the diet devoid of pyridoxine, riboflavin, or biotin. The biotin-deficient diet was modified by replacement of half the casein by uncooked powdered egg albumin. Radio graphs for determination of bone density and skeletal growth were taken initially and after 25, 45, and 67 days. Radiation at the rate of 10 r per day retarded tibia growth and tibia density in pyridoxine-deficient rats, affected to a slight extent the tibia density of riboflavin-deficient rats, but did not appear to affect either density or growth of the tibia in biotin-deficient rats or rats receiving adequate diet.

HARTWEG, H. & G. BOWING. The effect of vitamin B_6 in radiation damaged organisms. Investigations on the tryptophan metabolism of X-irradiated animals. Strahlentherapie 106:289-93, 1958. 369.

W.b. X-irrad. of 600 r given to rats entails a latent deficiency of vit. B_6 which becomes manifest after administration of 100 mg tryptophane by increased excretion of xanthurenic acid in the urine. Supply of 1 mg B_6, maintained for 2-3 days, prevents this irregularity of the protein metabolism, but has no influence on the course of the leukopenia.

KALMYKOVA, Z. I. The problem of the mechanism of action of pyridoxine (vitamin B_6) in acute radiation injury. Patolog. Fiziol. Eksp. Terap. 4: no. 1, 32-38, 1960. OTS 60-11, 828; JPRS: 2931. 370.

Rabbits and rats were exposed to 800 r of Co^{60} gamma-radiation, and guinea pigs to 450 r. Pyridoxine was given orally in aqueous solution, 0.3 to 3.0 mg/kg. Administration of B_6 for 1 wk before irrad. was beneficial but after irrad. it was harmful. These effects were associated with the histamine-forming function of pyridoxine and with the contents of histaminase in the body which destroys histamine. Administration of pyridoxine before irrad. increased histaminase levels and simultaneous administration of antihistaminic (dimedrol) with B_6 after irrad. offset the deleterious effect of the latter.

KOCH, R. & U. SCHMIDT. Investigations of biological radiation protection xxxiv. Radiation protection of B_6 derivates with SH-groups in the pyridoxine ring. Strahlentherapie 113:89-99, 1960. 371.

After oral administration to mice up to 2 hr before w.b. X-irrad. 5-mercaptopyridoxine, 4-desoxy-5-mercaptopyridoxine, and 5-mercaptopyridoxine-thioacetate had protective effects, but 5-mercaptopyridoxine disulfide , 4,5-dimercaptopyridoxine and 4-mercaptopyridoxine had not. It is assumed that the position of the sulfhydryl groups in the pyridoxine ring in position 5 is specific for radioprotective effects.

MacFARLAND, M. L., M. V. PETERS, R. M. BALLANTYNE, & E. W. McHENRY. Pyridoxine and experimental X-radiation injury in rats. Am. J. Physiol. 163: 394:99, 1950. 372.

Pyridoxine deprivation was not found to increase the susceptibility of rats to X-ray damage and irrad. did not affect the concentration of total vit. B_6 in the livers of either deficient or control animals.

C. TISSUE LEVELS AND EXCRETION

See also nos. 325, 328, 372.

SONG, C. S., W. N. PEARSON, & W. J. DARBY. Effects of anorexia and X-irradiation on vitamin B_6 excretion in rats. Am. J. Physiol. 184: 309-11, 1956. 373.

The increase of vit. B_6 excretion (from 2μg to 6-12μg) found after 500 r X-irrad. of rats is a reflection of anorexia and is not due to tissue changes. There is a marked increase in urinary volume, from 10 ml or less per day to 25-75 ml.

XIII. FOLIC ACID (FOLACIN, FOLINIC ACID, CITROVORUM FACTOR)

A. CLINICAL STUDIES

DAVIS, P. L. Folic acid and bone marrow in radiation therapy. Am. J. Med. 1:634-35, 1946. 374.

Of 122 patients with lymphoblastoma treated with radiation therapy and transfusions, 17 received folic acid alone without demonstrable effect on the course of the disease. 96 were treated with folic acid and routine therapy. This seemed to decrease deleterious and depressant effects of radiation therapy in some manner, i.e., less transfusions needed, shorter periods of hospitalization, and beneficial influence on the course of disease.

WATSON, C. J., W. H. SEBRELL, J. L. McKELVEY, & F. S. DAFT. Possible effectiveness of L. casei factor (folic acid) concentrates on refractory anemia and leukopenia with particular reference to leukopenia following radiation therapy. Am. J. Med. Sci. 210:463-70, 1945. 375.

Seven patients with leukopenia following X-ray therapy showed an increase in white cell count after administration of L. casei factor, 5 mg per os.

B. LABORATORY STUDIES

See also nos. 252, 320, 321, 395, 396, 489.

ANON. Vitamins and radiation injury. Nutrition Rev. 6:336-38, 1948. 376.

Influences of folic acid and pyridoxine, esp. Goldfeder et al.

ADAMS, W. S. & J. S. LAWRENCE. The negative effect of folic acid on irradiation leukopenia in the cat. Am. J. Med. Sci. 216:656-60, 1948, 377.

The prophylactic and therapeutic administration of folic acid to cats did not alter the occurrence or extent of leukopenia caused by exposure to 200 r w.b. roentgen irrad.

BLAIR, H. A. Biological effects of external radiation. UR 174, 1951. 378.

a. Folic acid (0.1 mg) and citrovarum factor (folinic acid, 200,000 units) were administered pre- and post-irrad. (w.b. X) to rats. No effects were noted. b. Diets varying in the relative concentration of proteins, fats, and carbohydrates were fed to rats given 625 r w.b. X-irrad. There were no significant alterations in survival.

BUCHANAN, D. J., W. N. PEARSON, C. AMARASINGHAM, G. W. HUDSON, & W. J. DARBY. Citrovorum factor and irradiation injury. Am. J. Physiol. 175:437-39, 1953. 379.

Daily i.p. injection of mature female rats with 1 mg citrovorum factor prior to and following w.b. X-irrad. failed to alter the clinical course, the leukopenia, or the subsequent leukopoiesis.

BURDICK, K. H., G. O. BALLENGEE. The biological and medical aspects of ionizing radiation. iv. The effect of folinic acid, S. F., on hematopoiesis following X-radiation. USAF School of Aviation Medicine, 21-47-005, Rpt. No. 4, 1952. (File No. NP 42, 71). 380.

Rats were given 570 r X-irrad. without treatment or with: 1.0 mg folinic acid ½ hr before and 0.5 mg/day for 20 days after; 5.0 mg folinic acid 24 hr before and 0.5 mg/day for 20 days after; or 0.5 mg folinic acid 24 hr after irrad. All doses were ineffective as a stimulant of hematopoiesis.

CHAIKOVSKAYA, M. Ya., O. S. SERGEL, & G. N. ELPATEVSKAYA. Complex treatment of radiation sickness in blood loss. Vestn. Rentgenol. Radiol. 34:47-52, 1959. 381.

Combined methods of therapy were tested in dogs irrad. at 500 r including vit. C, B_{12}, P, and folic acid, antibiotics, etc. Folic acid coupled with vit. B_{12} promoted and accelerated the regeneration of red blood cells.

CRONKITE, E. P., J. C. TULLIS, C. TESSMER, & F. W. ULLRICH. Failure of folic acid to influence lethal radiation illness in swine. Proc. Soc. Exp. Biol. Med. 73:496-97, 1950. 382.

Intramuscular injection of 45 mg of folic acid per day did not influence clinical or hematologic characteristics of swine exposed to 400 r w.b. X-irrad.

FURTH, F. W., M. P. COULTER, J. SHRIER, & J. MARKHAM. A study of the protective and therapeutic effect of folic acid and the citrovorum factor on the X-irradiated rat. UR-174, 1951. 383.

Rat survival and hematology following 700 r w.b. X-irrad. was unaffected by the following i.p. treatments: citrovorum factor, 200,000 units per day 5 days before and 28 days after exposure (I) or only 28 days after (II); folic acid, 0.1 mg I or II. Basal diet was Fox Chow.

GOLDFEDER, A., L. COHEN, C. MILLER, & M. SINGER. Agents influencing experimental radiation injury; effects of folic acid and pyridoxine. Proc. Soc. Exp. Biol. Med. 67:272-78, 1948. 384.

Mice were injected intramuscularly 7 days before and 13-15 days after exposure to 350 r of w.b. X-irrad. with either 15 μg of folic acid or 50 μg of pyridoxine hydrochloride. Both vit. significantly extended survival time and reduced 30-day mortality.

JACOBSON, L. O., Ph. STEARNER, & E. SIMMONS. Effect of folic acid on radiation induced anemia and leukopenia. J. Lab. & Clin. Med. 32: 1425, 1947 & Proc. Central Soc. Clin. Res. 20:34, 1947. AECU-78; ANL-4125 rev., 1948. 385.

Folic acid was administered enterally or parenterally to humans given P^{32} i.v. rat given Sr^{89} i.p., and rabbits exposed to single w.b. X-irrad. Leukopenia and macrocytic anemia were unaffected by treatment.

LIMPEROS, G. Alteration of the mortality of roentgen irradiated mice by chemical means. Am. J. Roentgenol. 67:810-16, 1952. 386.

I.p. administration of thiourea to mice before w.b. X-irrad. (450, 500, and 600 r) was found to decrease mortality. Addition of folic acid i.p. and in drinking water reduced effectiveness of thiourea.

STEARNER, S. P. Effects of folic acid on the anemia induced by X-irrad. Proc. Soc. Exp. Biol. Med. 69:518-21, 1948. 387.

Rats were given 15 μg folic acid daily for 22-40 days after 657 r X-irrad. Macrocytic anemia was not affected by this treatment.

STEARNER, S. P. & L. O. JACOBSON. The effect of folic acid on the response of the peripheral blood of the rat to strontium-89. CH-3830, 1947 (Also L. O. Jacobson et al, AECU-78, ANL-4125, rev. 1948). 388.

Folic acid had no effect on the macrocytic anemia or leukopenia in rats given 4.2 microcuries per g Sr^{89}.

C. TISSUE LEVELS AND EXCRETION

See also nos. 325, 328.

GUGGENHEIM, K., S. HALEVY, A. HOCHMAN, & M. BEN-PORATH. The effect of X-irradiation on the metabolism of folic acid in rat organs. Radiation Res. 12:567-74, 1960. 389.

Folic acid and citrovorum factor were measured in tissues of rats subjected to 400 or 600 r of X-irrad. In spleen both FA and CF were diminished a few hr after irrad., CF more than FA. Levels remained low for several days. In testes, FA and CF decreased from 10th day on but ratio maintained constant. No significant changes occurred in thymus, liver, or kidneys.

XIV. V I T A M I N B_{12} (C Y A N O C O B A L A M I N E)

See also entries under VII. B. 1. Cobalt

A. CLINICAL STUDIES

See also no 314.

RENNER, W. Therapeutic effects of vitamin B_{12} and similar chemical substances on radiation sickness and on conditions caused by malignant tumors. Strahlentherapie 85:342-46, 1951. 390.

Vit. B_{12} was used successfully in counteracting radiation sickness and tumor toxicity. Cobalt porphyrines were ineffective.

B. LABORATORY STUDIES

See also nos. 157, 252, 317, 320, 321, 381, 483.

BELOUSOVA, O. I. & E. K. GRABOVENKO. The use of vitamin B_{12} and B_6 under conditions of the repeated effect of X-rays. Med. Radiol. 4: no. 10, 41-46, 1959. JPRS-2707, p.36-43. 391.

20 r X-irrad. were given daily for 20 days to 35 dogs. These received 15 µg of vit. B_{12}/day to a total of 405 µg and either (I) 50 mg B_6/day for 6 days orally or (III) 25 mg/day i.p. or a combination of I and II. I and II did not prevent damage to hematopoiesis, but promoted faster return to normal. Combination of I and II was most effective. Two to 3 weeks after radiation the blood picture was almost normal.

BERDYSHEV, G. D. The action of vitamin B_{12} on the blood of normal and irradiated animals. Problems Hematol. Blood Transfusion (Engl. tr.) 3:284-89, 1958. Probl. Gemat., Pereliv. Krovi 3: no. 5, 9-14, 1958. 392.

No beneficial effect in terms of hematopoiesis was seen in mice or guinea pigs given vit. B_{12} and exposed to moderate doses of X-irradiation.

BETZ, H. Factors controlling the hemopoietic regeneration in whole-body-irradiated rats. Rev. Hemat. 8:489, 1953. (Radiobiology symposium, Proc. Liege. Aug-Sep 1954). 393.

Normal and adrenalectomized rats were given lethal doses of 800 r X-irrad. If daily injection of 2.5 mg cortisone and 5 i.u. somatotropic hormone/day were given, 25% of the adrenalectomized rats survived and showed extensive regeneration of the spleen, lymph nodes, and marrow. The action of testosterone propionate and vit. B_{12} is similar to that of somatotropic hormone.

CARTER, R. E., E. BUSCH, & V. STRANG. The effect of vitamin B_{12} on the leukopenia induced by radiation. Blood (J. Hematol.) 5:753-57, 1950. 394.

Crystalline vit. B_{12} administered via intramuscular injection, in single and in multiple doses, produced no effect on the leukopenia induced in rats by 400 r X-irrad.

CORNATZER, W. E., C. ARTOM, G. T. HARRELL, JR., & D. CAYER. Beneficial effects of vitamin B_{12} and folic acid on recovery from internal radiation by P-32. Proc. Soc. Exp. Biol. Med. 76:552-54, 1951.395.

Addition of luxus amounts of folic acid or FA plus vit. B_{12} to experimental diets had no effect on survival of mice injected with P^{32} in the higher dose range ($> LD_{50/21}$). When sulfasuxidine was added to the diet and when the dose of P^{32} was below $LD_{50/21}$, addition of FA and B_{12} significantly increased survival time and percentage of survivors at both 21 and 56 days. The further addition of menadione and biotin did not enhance the beneficial action of B_{12}.

KUDRYASHOV, V. A., G. V. ANDREENKO, & N. P. SYTINA. Effects of vitamin B_{12} and folic acid on the thromboplastic activity during experimental radiation disease. Dokl. Akad. Nauk. S.S.S.R. 118:701-04, 1958. 396.

Experiments were made to determine the effects of vit. B_{12} and folic acid on the thromboplastic activity of blood in rats exposed to 400-800r. Exposure to 400-650 r caused a drastic drop in the thromboplastic activity induced by the lack of blood prothrombokinase. Intramuscular injections of vit. B_{12}, folic acid or both did not produce positive results in the preservation or restoration of thromboplastic activity. However simultaneous injection of vit. B_{12} and folic acid i.v. to rats exposed while protected in the lumbar region by a lead plate resulted in considerable retention of the thromboplastic activity and speeded up restoration.

C. TISSUE LEVELS AND EXCRETION

See also no. 97.

BERDYSHEV, G. D. A study of the content, absorption and deposition of vitamin B_{12} in the liver in radiation sickness. Problems Hematol. Blood Transfusion. (Engl. tr.) 4:10-14, 1959. Probl. Gemat. Pereliv. Krovi 4: no 3, 10-13, 1959. 397.

No changes were seen in liver or serum B_{12} content of animals exposed to lethal doses of radiation.

XV. PANTOTHENIC ACID

See also nos. (Coenzyme A) 154, 155; (Royal Jelly) 534.

A. CLINICAL STUDIES

See 313.

B. LABORATORY STUDIES

See also nos. 318, 339.

ARTOM, C. Effects of pantothenic acid and its analogs in radiation injury by P^{32}. Proc. Soc. Exp. Biol. Med. 86:162-65, 1954. 398.

A significant protection against the injurious effects of P^{32} was observed by the administration of pantothenic acid to mice on a deficient diet containing sulfasuxidine. Pantoyltaurine was almost as effective. Free taurine also exerted some protection. ω-methyl pantothenate was totally ineffective. The protective action of PA was not modified appreciably by the presence or absence of para-aminobenzoic acid in the diet. Reference is made to unpublished data showing that α-tocopherol did not alleviate and, at higher doses, even increased the severity of damage from P^{32}.

BROWN, S. O. & G. ADAM. Survival of chronically irradiated mice maintained on pantothenic acid-deficient diets. In: The influence of dietary deficiencies on the survival of albino rats and mice subjected to continuous low intensity radiation. DA-007-49-MD-957, 1960. 399.

Groups of 50 mice were fed an adequate synthetic diet, fat-free but containing 2 dr methyl linoleate per 100 g or this diet devoid of pantothenic acid and exposed to 10 r/day (Co^{60}) radiation or were not irrad. Mortality due to deficiency was unaltered by radiation. Males were more susceptible to deficiency than were females.

GARDELLA, J. W. & E. J. LICHTLER. Resistance of coenzyme A to radiation. (Abstr.) Fed. Proc. 15:70, 1956. 400.

In vivo, 1000-1600 r w.b. X-irrad. did not measurably alter, within 8 hr, the pre-irrad. content of CoA of any of the following tissues (in units of CoA per g wet weight): Wistar rat liver, 130; rat thymus, 18.8; Strain A mouse liver, 112; Yoshida sarcome, 7.6; duckling liver, normal 81.4, and pantothenic acid-deficient, 45.5.

C. TISSUE LEVELS AND EXCRETION

See 311.

XVI. C H O L I N E

A. CLINICAL STUDIES

See 245.

B. LABORATORY STUDIES

See also nos. 128, 151, 318, 496.

CARROLL, H. W., A. P. SPIVACK, & R. W. BRAUER. Attempts to reproduce cirrhosis of the liver in rats following total-body X-irradiation. Naval Radiological Defense Lab., San Francisco, Calif. NRDL-TR-304. 1959. 401.

A histopathological study of the liver following w.b. X-irrad. was made using a low protein diet as a tool for amplifying latent injury. Experiments were designed so that rats were placed on the experimental diet before exposure, during exposure, at the end of the exposure period or after an extended period of recovery from the acute radiation illness. W.b. X-irrad., either 475 r in a single exposure or 200 r/week for 5 consecutive weeks (total 1000 r), had no demonstrable effect upon onset or severity of cirrhotic lesions when compared to non-irradiated rats on the same diet for the same period of time. Fibrous lesions of the liver in these experiments appeared to be dietary in origin and were all but eliminated by choline supplementation.

C. TISSUE LEVELS AND EXCRETION

BUCHANAN, D. J., W. J. DARBY, E. B. BRIDGEFORTH, G. W. HUDSON, & J. A. EFNER. Choline studies in rats following whole-body X-irradiation. Am. J. Physiol. 174:336-40, 1953. 402.

Female rats fed a casein (25%) diet containing 0.5% choline hydrochloride were subjected to 500 r X-irrad. (including backscatter). There was no significant change in urinary choline excretion following irrad. Plasma phospholipid choline was increased significantly 48 hr after massive irrad. (1000 and 2000 r.).

XVII. B I O T I N

See 311, 327, 368, 395.

XVIII. P A R A-A M I N O B E N Z O I C A C I D

See 151, 317, 320, 398.

XIX. I N O S I T O L

See 318.

XX A S C O R B I C A C I D (V I T A M I N C)

A. CLINICAL STUDIES

See also nos. 314, 315, 410, 423.

CARRIE, C. Prophylaxis of leukopenia. Acta Unio. Intern contra Cancrum 4:816-17, 1939. 403.

By administering vit. C before irrad. (2-3 days) leukopenia could be avoided. In prolonged radiotherapy vit. C should be given in the days before and during treatment.

CARRIE, C. Therapy of X-ray leukopenia. Strahlentherapie 63:183-87, 1938. 404.

Intramuscular injections of 500 mg l-ascorbic acid were particularly effective against leukopenia when given at initiation of treatment.

CLAUSSEN, A. Leukopenia treated with ascorbic acid. Acta Radiol. 23: 95-98, 1942. 405.

Improved leukocyte levels were seen in patients given 0.2 to 0.5 g of ascorbic acid following local radiation up to 14000 r.

DeCARLOS, R. Leukopenia due to X-rays. Prophylaxis and therapy with vitamin C(Ascorbin). Gazz. Sanit. 18:92-97, 1947. 406.

Author concludes that vit. C (50 mg/day i.v. or intramuscularly) has prophylactic and curative value in leukopenia due to radiation therapy in 30 patients. Control data are not given.

DEUCHER, W. G. Observation on vitamin-C economy in tumor patients. Strahlentherapie, 67:143-51, 1940. 407.

Vit. C requirements in tumor patients are very high -- about 6000 mg until saturation is reached. Deficiency of vit. C. does not seem to be caused by X-irrad. Administration of large amounts of "redoxon" (up to 4 g/day) had remarkably good results on the well-being of the tumor patients and prevented the ill effects of radiation.

ELLIS, F. Volume dosage in deep X-ray therapy: The estimation of volume dosage in deep X-ray therapy for clinical purposes. Pt. ii. The correlation of biological effects with volume dose. Brit. J. Radiol. 15:194-201, 1942. 408.

"Redoxon" (ascorbic acid) was given in large quantities, 300-600 mg daily, or "Torantil " (histaminase). Vomiting was prevented by both; ascorbic acid also caused improvement in the leukocyte count.

MARTIROSOV, K. S. Cited in Yusipov, V. S. Med. Radiol. 4: no.9, 79-81, 1959. 409.

"Pigment function" of liver is affected by local X-ray therapy and is benefited by ascorbic acid treatment. (No literature citation is given; not seen).

MILLER, T. R. & B. SOKOLOFF. A vitamin C-free diet in radiation therapy of malignant diseases. Am. J. Roentgenol. Rad. Therapy & Nucl. Med. 73:472-80, 1955. 410.

Guinea pigs kept on low vit. C diet survived radiation better than those with regular vit. C diet; carcinoma of animals on vit. C-free diet grows slower. X-ray therapy on 26 patients kept on vit. C-free diet for 4-6 months had good results. Radiation treatment was started when ascorbic acid concentration of blood was down to 0.02-0.01 mg/100 cc or after about 14 days, and low vit. C diet was continued for 4-6 months after irrad. Treatment was successful in malignancy of lymphatic system or localized cancer without metastases.

SMITHERS, D. W. The control and treatment of radiation reactions. Brit. J. Radiol. 15:233-36, 1942. 411.

Vit. C was given in conjunction with sodium bicarbonate to promote storage of the vit. in the body, with good results.

SZENES, T. Action of ascorbic acid in Roentgen irradiation of tumors and tumorous proliferations. Strahlentherapie 71:463-71, 1942. 412.

Tumors cause ascorbic acid deficiency, and the daily requirement of ascorbic acid is increased. After successful radiation therapy ascorbic acid is excreted in urine in greater amounts than administered. It evidently was freed from the catabolized neoplasms. No effects of ascorbic acid on X-ray therapy results were observed; radiation sickness is less severe but not entirely prevented. Ascorbic acid causes leukocytosis but does not prevent occurrence of X-ray leukopenia.

VLADIMIROVA, V. S. On the therapy of the complications of radiotherapy of carcinoma of the uterus with ascorbic acid. Dissertation, Kiev, 1953. 413.

General state of health and detoxication function of liver were promoted by administration of ascorbic acid; (cited in ref. 423).

B. LABORATORY STUDIES

See also nos. 148, 157, 167, 321, 323, 381, 423, 454, 458, 480, 489, 490, 491.

CAFFARATTI, E. Influence of cysteine associated with ascorbic acid on radiation-induced variations in the plasma protein fractions. Radiobiol. Radioter. Fis. Med. (Bologna) 8:144-52, 1952. 414.

Guinea pigs were injected intramuscularly with 750 mg of cysteine and 150 mg of ascorbic acid prior to 800 r w.b. X-irrad. Plasma albumin, globulin , and total protein were measured. Treatment off-set the post-irrad. percentage increase of gamma globulin.

CAFFARATTI, E. Some substances with reducing action (cysteine, thioglycolic acid, ascorbic acid, combined cysteine and ascorbic acid) as protective agents in biochemical X-ray injuries. Radiobiol. Radioter. Fis. Med. (Bologna) 4:378-84, 1951. 415.

Mice were injected i.v. 5 min before irrad. with per kg: 500 mg cysteine; 540 mg thioglycolic acid; 100 mg ascorbic acid; or cysteine plus ascorbic acid. Twenty-one days after 800 r irrad. survival was 45% in untreated controls; 80% in cysteine; 50% in thioglycolic acid; 50% in ascorbic acid; and 94% in cysteine ascorbic acid treated animals. Thus, ascorbic acid was not beneficial alone but was synergistic with cysteine.

CARRIE, C. & O. SCHNETTLER. Prevention of the Rontgen ray leukopenia. Strahlentherapie 66:149-54, 1939. 416.

Rabbits were given 600 r X-irrad. and 200 mg vit. C("Cebion"). Vit. C injections given previous to irrad. had the best effects in combating leukopenia, but leukopenia was improved also by post-irrad. injections.

DEL MORO, V. M. Effects of a combination of cysteine and ascorbic acid on the contents of pyridine nucleotides and lactodehydrogenase in rats exposed to irradiation. Radiobiol. Latina 2:95-98, 1959. 417.

Combined administration of these compounds before, but not after, irrad. increased enzyme concentration in liver.

ELLINGER, F. Pharmacological studies on irradiated animals. ii. Effect of cortisone on X-ray mortality of mice. Proc. Soc. Exp. Biol. Med. 80:214-17, 1952. 418.

Administration, intramuscularly, of cortisone to mice after irrad. (LD_{50} and $_{25/14}$) was detrimental. Ascorbic acid, 15 and 5 mg per day, intramuscularly, for 14 days, did not modify the detrimental effect.

HUBER, R., W. BRUCKER, & E. SCHRODER. The effect of dehydroascorbic acid on the survival of X-irradiated mice. Acta. Biol. Med. Germ. 4:529-34, 1960. (Zentr. ges. Radiol. Jan 1961 (Abstr.)). 419.

Dehydroascorbic acid given immediately after irrad. increases survival of mice, particularly after sublethal irrad. (500 r). Dithiocarbamate given before exposure does not decrease the therapeutic effect of DHAsc even though known as an inhibitor of ascorbic acid oxidase.

KALNINS, V. The effect of X-ray irradiation upon the mandibles of guinea pigs treated with large and small doses of ascorbic acid. J. Dental Res. 32:177-88, 1953. 420.

X-irrad. induced lesions of the bone and mandibular incisors were studied histologically in guinea pigs which had received every other day 50 or 1 mg of ascorbic acid. Scorbutic changes were seen in the latter. Retention of functional characteristics was superior in the group given 50 mg dosage.

LOISELEUR, J. & G. VELLEY. Curative treatment of radiolesions following administration of a lethal dose of X-rays. Compt. Rend. Acad. Sci. Paris, 231:529-31, 1950. 421.

Rabbits were exposed to 950 r w.b. X-irrad. 10 min after injection (i.p.) with 2 g ascorbic acid plus 2 g cysteine or water. Survival was 60% as opposed to 100% lethality in controls.

YUSIPOV, V. S. The effect of ascorbic acid on the carbohydrate function of the liver and the survival rate of animals with acute radiation sickness. Med. Radiol. 4: no.9, 78, 1959. JPRS-2706: 43-4. 422.

Changes in carbohydrate tolerance were seen in rabbits given 500 r, immediately after irrad. and during the period of acute illness but absent in the latent period, as assessed by blood sugar and lactic acid values and galactose tolerance tests. Administration of ascorbic acid (a.a.) prior to irrad. had a damaging effect upon these parameters and on survival. Similar negative effects were seen when a.a. was given 1 min after irrad. Beneficial effects were recorded when a.a. was given 20 hr after exposure. Administration of a.a. before irrad. interfered with the increase in liver glycogen seen in control irrad. animals.

YUSIPOV, V. S. The role of ascorbic acid in radiation sickness. Med. Radiol. 4: no.9, 79-81, 1959. 423.

A discussion and review, in which it is noted that radiosensitive tissues are high in ascorbic acid and suggested that most radioprotective agents are antioxidants and tend to prevent conversion of a.a. to dehydro-a.a., a toxic end-product.

C. TISSUE LEVELS AND EXCRETION

Aee also nos. 96, 315, 324, 325, 423, 428.

BERNARDINI, A. & S. CALTABIANO. Action of X-rays on the metabolism of ascorbic acid. Boll. Soc. Ital. Biol. Sper. 31:293-95, 1955. 424.

X-irrad. decreased the content of ascorbic acid in various organs of the rat.

BERNARDINI, A. & S. CALTABIANO. Effect of Röntgen rays on ascorbic acid metabolism. Boll. Soc. Ital. Biol. Sper. 29:1869-72, 1953. 425.

W.b. X-irrad. (350 r) of rats causes prolonged reduction in urinary ascorbic acid and losses from liver, spleen, and adrenals.

BOZHENKO, L. V. Effect of radiation sickness on the adrenal cortex. Med. Radiol. 2: no. 4, 44-50, 1957. 426.

Ascorbic acid level of the adrenals was reduced by 27% within the first few hr in rats exposed to 300 r and 600 r of radiation. Weight of the adrenals decreased between days 3-7 by 7% at 300 r and between days 3-14 by 18% at 600r. Ascorbic acid content rose by 8 and 18%, respectively. This was followed by a period of normalization. Exposure to 1500 r reduced the ascorbic acid level by 35% thereafter retaining this level until death, although the weight of the adrenals continued to rise.

DOLGAVA, T. J. The effects of a single exposure to X-rays on the ascorbic acid content of the organs in guinea pigs. Vopros. Med. Khim. 4: no.2, 166-68, 1960. 427.

In guinea pigs 600 r induces a decrease of ascorbic acid content in the brain, adrenals, testicles, spleen, and small intestine, demonstrable from the 1st to 7th day following irrad. In the liver a significant alteration of ascorbic acid concentration was observed.

GLUSHAKOVA, N. E., F. M. LAGUTO, & O. S. LUCHENOK. Vitamin C in the liver and the wall of the small intestine in radiation sickness in animals synthesizing ascorbic acid. Med. Radiol. 5: no.4, 86-87, 1960. JPRS-5016:222-23. 428.

Prolonged disturbance in ascorbic acid metabolism was observed. Immediately after irrad. capacity of hepatic tissue to reduce dehydro-ascorbic acid was impaired. Tissue levels at various times are given.

KLEIN, P. D., D. T. HANDA, & R. W. SWICK. Fate of ascorbic acid in early radiation damage. Proc. Soc. Exp. Biol. Med. 90:204-08, 1955. 429.

There were no gross changes in concentration or total content of ascorbic acid (a.a.) within 72 hr after 600 r of X-irrad. in rat liver, brain, pancreas, testes, muscle, kidney, or brown adipose tissue. Thymus, lymph nodes, and spleen showed a drop in a.a. concentration within 4 hr and the content of a.a. continued to drop throughout the period studied. Intestinal mucosa showed a sharp increase in a.a. concentration during the first 4 hr followed by a gradual decline. No differentiation was made between oxidized and reduced forms of a.a. in analyses.

KLIMENKO, O. S. Effect of single total-body X-irradiation on the content of ascorbic acid in the blood and tissues. Fiziol. Zh., (Kiev). 3: no.3, 117-21, 1957. 430.

600 r w.b. X-irrad. of the rabbit caused ascorbic acid content reduction of the whole blood within 10-20 min. Protein absorption capacity index of the blood rose, pointing to a decrease in the vit. C saturation of the whole organism. Ascorbic acid content of adrenals was lowered after 600 and 900 r exposure; of brain tissue only after 900 r; in other tissues the ascorbic acid content remained normal.

KRETZSCHMAR, C. H. & F. ELLIS. The effect of X-rays on ascorbic acid concentration in plasma and tissues. Brit. J. Radiol. 20:94-99, 1947. 431.

Patients undergoing radiotherapy exhibited decreased levels of serum ascorbic acid.

MONIER, M. & R. WEISS. Increased excretion of dehydroascorbic acid and diketogulonic acids by rats after X-ray irradiation. Proc. Soc. Exp. Biol. Med. 81:598-99, 1952. 432.

Increased excretion of the compounds cited was found after 800 r w.b. X-irrad. Excretion of reduced ascorbic acid was unchanged.

OSTER, H. L., A. L. KRETCHMAR, & F. H. BETHELL. Effect of whole-body X-irradiation on ascorbic acid of rat tissues. Proc. Soc. Exp. Biol. Med. 84:470-73, 1953. 433.

A dose of 710 r reduced the ascorbic acid content of various organs and blood of Long-Evans strain rats. In Wistar rats, 1000 r did not result in such reduction except in the adrenals; in some organs a tendency to increase was noted.

POLYKARPOVA, L. I. Ascorbic acid metabolism in the wall of the aorta in the development of radiation damage. Biokhimia 25: 465-69, 1960. (Engl. transl.) 25:356-58, 1960 434.

Guinea pigs and rabbits were subjected to a single lethal-dose irrad. with Co^{60}. In guinea pigs ascorbic acid was reduced between the 3d and 5th day after irrad.; at the same time dehydroascorbic acid sharply increased on the 3d day after irrad. In rabbits the level of ascorbic acid in the walls of the aorta at first rose and then returned to the original level while the level of dehydroascorbic acid remained unaffected. The dehydroascorbic acid/ascorbic acid ratio increased in the guinea pigs on the 3d to 5th day after irrad. It remained unaffected in the rabbits. The development of radiation disease in guinea pigs was accompanied by a considerable deficit of ascorbic acid in the wall of the aorta; no such effect was noted in the rabbits.

SKULME, K. A. & E. A. KAIROV. Ascorbic acid metabolism in radiation sickness. Trudy Inst. Eksptl. Med., Akad. Nauk Latv. S.S.R 14: 77-85, 1957. 435.

Ascorbic acid (a.a.) content of blood in ostensibly healthy persons was at a higher level than in cancerous patients. Injections of 50-100 mg of a.a./day into patients during irrad. therapy failed to uphold the level of a.a. or at the most aided in maintaining the original a.a. level in the blood. Irregular administration of a.a. even in large quantities failed to maintain a balanced level of a.a. Patients having malignant growths eliminated a.a. via the urine in small amounts, despite the fact that their blood a.a. content was low.

Breakdown of the malignant tissue under the effects of radiation enhanced a.a. elimination via the urine. A.a. of normal test persons subjected to light effects of ionizing rays varied greatly with the season of the year as a reflection of the amounts of a.a. with the food preparations.

(Yusipov refers to a paper by Skulme and Pranis, L.Yu., Reports at the 4th All-Union Conference on Vitamins, p. 107, Moscow, 1957, on same general topic).

STEPANOVA, M. M. & I. I. IVANOV. The problem of the metabolism of vitamin C and aromatic amino acids in radiation sickness. Vopros Med. Khim. 4:370-72, 1958. JPRS-L-692-N. 436.

No serious disturbances in metabolism of the amino acids or marked changes in vit. C levels were observed during radiation sickness in guinea pigs.

TRETYAKOVA, K. A. Cholesterol and ascorbic acid content of rat adrenals after ionizing radiations. Probl. Endokr. Gormonoter, 3: no. 3, 72-74, 1957. 437.

Ascorbic acid and cholesterol content of rat adrenals decreased immediately after irrad. (700 r, X). Seasonal variance was noted.

VENTERS, K. D., E. E. PAINTER. Pituitary and adrenal ascorbic acid in X-irradiated rats. (Abstr.) Fed. Proc. 10:141, 1951. 438.

There was an increase in pituitary and decrease in adrenal ascorbic acid content.

WEXLER, B. C., R. PENCHARZ, & S. F. THOMAS. Adrenal ascorbic acid and histological changes in male and female rats after half-body X-ray irradiation. Am. J. Physiol. 183:71-74, 1955. 439.

Half-body X-irrad. (625 r) was found to cause much greater depletion and more active repletion of adrenal ascorbic acid in rats than w.b. X-irrad.

WEXLER, B. C., R. PENCHARZ, &. S. F. THOMAS. Adrenal ascorbic acid in male and female rats after total body X-irradiation. Proc. Soc. Exp. Biol. Med. 79:183-84, 1952. 440.

A greater decrease was seen in males than in females.

ZHORNO, L. Ya. The changes in the content of ascorbic acid in the adrenals of the guinea pig after X-ray irradiation. Med. Radiol. 1: no. 1, 79-87, 1956. 441.

Tissue and blood levels decrease after irradiation. (Not seen. Cited by Yusipov).

XXI. FLAVONOIDS (VITAMIN P, RUTIN, HESPERIDIN, CHALCONES, CITRUS BIOFLAVONOIDS)

A. CLINICAL STUDIES

See also no. 448.

ARONS, I., J. FREEMAN & S. WEINTRAUB. Bio-flavonoids in radiation injury. iii. Clinical studies. Brit. J. Radiol. 27:696-98, 1954. 442.

Bioflavonoids, 600 mg per day, were given 5-7 days before and during the whole course of radiation therapy of 403 patients. Tolerance was markedly increased in this group as compared with 613 control cases.

COHEN, A. & L. COHEN. Experimental radiotherapy of abdominal cancer. ii. Effect of a flavonone (rutin) on radiation reactions. Brit. J. Radiol. 25:601-05, 1952. 443.

Treatment with rutin prior to irrad. of the upper abdomen raises the tolerance of the rat by 50%. Intensity of skin reaction is also diminished, but delayed damage to internal organs is not prevented.

B. LABORATORY STUDIES

See also nos. 381, 488, 489, 490, 491.

ANON. Effects of flavones and ascorbic acid on radiation sickness. Nutrition Rev. 7:317-18, 1949. 444.

A review of the work of Field and Rekers.

ANON. Flavonoids and X-irradiation. Nutrition Rev. 10:242-43, 1952. 445.

A review with 10 references.

ARONS, I. & J. FREEMAN. Bioflavonoids in radiation injury. ii. Contact radiation in experimental cancer. Brit. J. Radiol. 27:642-44, 1954. 446.

Bioflavonoid extracts from citrus fruit increased the tolerance of rats to contact radiation, when they were administered prior to and after the exposure.

ARONS, I., J. FREEMAN, B. SOKOLOFF, & W. H. EDDY. Bioflavonoids in radiation injury. i. The effect of ionizing radiation on capillaries. Brit. J. Radiol. 27:583-85, 1954. 447.

Pre-treatment for 10 days with 600 mg per day of bioflavonoids (CVP) afforded protection to the capillaries of the nail bed in healthy humans given a single 200 r dose of X-irrad.

ARONS, I., B. SOKOLOFF, & R. DUTCHER. The protective action of flavonoids against radiation. Unio International Contra Cancrum 7:803-09, 1952. 448.

Rat studies same as reported in no. 449. Flavonoid administration decreased severity of skin reaction in 13 patients given deep X-ray therapy.

ARONS, I., S. WEINTRAUB, I. WRIGHT, B. SOKOLOFF, & R. DUTCHER. The protective action of flavonoids against radiation. In: 6th Internat. Congress of Radiology, p. 170, London, 1950. 449.

Rats were given a single w.b. dose of 800 r X-irrad. Mortality was 80% of 40 controls, but only 10% of 60 animals treated 7 days before and 23 days after irrad. with 5 mg of citrus flavonoids daily.

BLAIR, H.A. Biological effects of external radiation. Studies relative to the phagocytic activity of leukocytes in irradiated dogs and the effect of rutin on the X-irradiated dog. UR-205;48-59, 1952. 450.

Rutin therapy had no beneficial effect in dogs subjected to 450 r X-irrad.

CLARK, W. G., R. P. UNCAPHER, & M. L. JORDAN. Effect of flavonoids (vitamin P) on mortality from total body roentgen irradiation. Science 108:629-30, 1948. 451.

Guinea pigs fed Rockland Diet plus 0.2% ascorbic acid solution as drinking water were subjected to 200-225 r X-irrad. Thirty of 45 controls (67%) died; mortality was reduced to 35% (9 of 26) when a supplement of 0.2% calcium flavonate was given with the drinking solution 1 wk before and continuously after irrad.

CRONKITE, E. P., W. H. CHAPMAN, & F. W. CHAMBERS. Failure of a flavonoid to reduce radiation mortality in mice. Proc. Soc. Exp. Biol. Med. 76:282-84, 1951. 452.

Mice were given a total daily dose of 0.13 mg/g of rutin by subcutaneous injection 5 days before and 15 days after exposure to 750, 850, 950, or 1050 r X-irrad. The compound afforded no protection.

CRONKITE, E. P., D. C. ELTZHOLTZ, C. R. SIPE, W. H. CHAPMAN, & F. W. CHAMBERS. Failure of rutin to decrease the mortality of acute ionizing radiation illness in mice. Proc. Soc. Exp. Biol. Med. 70:125-28, 1949. 453.

Rutin was fed to mice in drinking water (10 to 13 mg/ml) or in food (20 mg/100 g). Mortality following 705± 11 r X-irrad. was about 40% in both control and treated groups but was attained earlier in the treated groups.

DAUER, M. & J. M. COON. Failure of rutin and related flavonoids to influence mortality following acute whole-body X-irradiation. Proc. Soc. Exp. Biol. Med. 79:702-07, 1952. 454.

No protection was afforded mice exposed to 500-800 r w.b. X-irrad. by: rutin complexed with piperazine hexahydrate, de-ionized rutin, quercetin, quercitrin, hesperidin, hesperidin-methyl-chalcone, dihydroquercitrin, naringen, Ca flavonate, xanthorhamnin, de-ionized morin, citrus vit. P or lemon juice infusion. In rats and guinea pigs exposed to acute w.b. X-irrad., rutin complex, hesperidin-methyl-chalcone, and citrus vit. P were without benefit when given alone or with supplemental vit. C.

ERSHOFF, B. H. & C. W. STEERS. Bioflavonoids and survival time of mice exposed to multiple sub-lethal doses of X-irradiation. Proc. Soc. Exp. Biol. Med. 105:283-86, 1960. 455.

Mice were fed a purified basal diet (24% casein, vit. C added) for 6 weeks and then exposed to 200 r w.b. X-irrad. weekly for 6 weeks (total 1200 r), and continued on diet for 135 days after 1st exposure or until death. Some of the mice were given dietary supplements at 2% or 4% levels of: hesperidin (I), lemon bioflavonoid complex (II), narigen (III), hesperidin-methyl-chalcone (IV), or rutin (V). I and II had no effect on survival but III, IV, and V were beneficial, particularly IV and V at the 4% level.

FIELD, J. B. & P. E. REKERS. Ionizing irradiation disease and a study of the protective nature of flavonones. MDDC-1672, 1948. 456.

Includes data given in other publications of these authors (457, 458,467) and the following: Rutin therapy (50 mg t.i.d. beginning 1 week in advance) did not alter the clinical course or mortality in dogs exposed to 450 r w.b. X-irrad. Administration of rutin to rats (subcutaneously, 5 mg per day beginning 10 days in advance or 10 mg perorally in the diet) did not decrease mortality following 700 or 750 r w.b. X-irrad. In fact, it appeared to be detrimental.

FIELD, J. B. & P. E. REKERS. Studies of the effects of flavonoids on roentgen irradiation disease. i. Protective influence of rutin in irradiated dogs. Am. J. Med. Sci. 218:1-15, 1949. 457.

Dogs were given a single dose of 350 r w.b. X-irrad., which was 60% lethal in untreated animals. Mortality was 36% with a flavonoid preparation from lemon peels. When rutin (50 mg perorally 3 times daily) was given 1 week before irrad. mortality was 33%; treatment only after irrad. resulted in 60-80% mortality; administration both before and after irrad. reduced mortality to 11%.

FIELD, J. B. & P. E. REKERS. Studies on the effects of the flavonoids in roentgen irradiation disease. ii. Comparison of the protective influence of some flavonoids and vitamin C in dogs. J. Clin. Invest. 28:747-51, 1949. 458.

A single total-body exposure to 350 r X-irrad. was 60% lethal to untreated dogs. Five flavones were beneficial when administered both pre- and post-irrad., yielding the following mortalities: rutin, 11%; hesperidin, 17%; epimerized d-catechol, 10%; homoeriodictyol and morin, 0%. Other flavonoids had little or no effect: quercetin, quercitrin, and naringen. Benzopyrone and coumarin increased radiosensitivity. Ascorbic acid (100 mg) alone had no effect but with quercetin was markedly protective. Inhibitors of hyaluronidase (dopa and Na gentisate) had no effect.

GRIFFITH, J. Q., JR., E. ANTHONY, E. P. PENDERGRASS, & R. PERRYMAN. Effect of rutin on recovery time from radiation injury in rats. Proc. Soc. Exp. Biol. Med. 64:332-33, 1947. 459.

Rats were given X-irrad. to one foot, 2385 r in a single exposure. Pellets of rutin (20 mg) were implanted every 3 days for 36 days, along the lateral aspect of the abdominal wall. Rutin appeared to hasten recovery time from erythema, swelling, and ulceration.

GRIFFITH, J. Q. & J. F. COUCH. Inhibition by rutin of capillary injury by alpha-radiation in rats. Blood 6:552-54, 1951. 460.

A convenient laboratory method is given for determining the amount of protection of capillary integrity afforded by rutin against alpha-radiation. Twenty mg of rutin given by pellet and 25 mg in solution gave good protection against up to 200 μc (given as radon ointment) of alpha-radiation.

HALEY, T. J. & S. MANN. Inability of flavonoids to modify roentgen ray irradiation mortality in guinea pigs. Proc. Soc. Exp. Biol. Med. 81:665-67, 1952. 461.

Rutin, hesperidin and its methylchalcone, and naringen were ineffective. There was an indication that post-irrad. medication with rutin may have increased the mortality rate.

HARTWEG, H. Hemotological investigation of the effect of protective material. Part v. The radiation reaction of spleen after the use of protective material. Strahlentherapie 103:559-63, 1957. 462.

Homologous bone marrow, cysteine, and vit. P effects on X-ray reaction of the spleen were tested in rats. Lead protection and preliminary treatment with vit.P led to regeneration 48 hr earlier.

KAPLAN, H. S. Failure of rutin to prevent post-irradiation death in mice. (Abstr.) ANL-4205, p.107, 1948. 463.

Mice were treated 3 days before and 2 weeks after 700 r w.b. X-irrad. with 1 cc i.p. daily of a solution containing 10 mg rutin in 1% triethanolamine. Controls received the vehicle. No protective effect was seen in lethality.

KOHN, H. I., P. W. TOBINETT, & M. N. CUPP. The effect of rutin upon the response of the rat to total-body X-irradiation. AECD-2176, 1948. 464.

Rutin, 5 mg per day, was administered subcutaneously or perorally beginning with the day of irrad. or 1 week before and continuing for at least 18 days. Treatment did not affect LD_{50}, survival following 2 sub-lethal exposures, coagulation time, thrombocyte count, total white cell count and hemorrhage into the lymph nodes of the gastrointestinal tract.

PARIS, R., E. VAIREL, & J. VAVASSEUR. Protective effect of flavone derivatives on mortality in irradiation of the rabbit and mouse. Ann. Pharm. Franc. 9:68-78, 1951. 465.

Rutin prevented the increase in capillary fragility of rabbits exposed to 700 r X-irrad. and slightly decreased mortality. At a dose of 800 r no benefit was seen. A diet low in green vegetables decreased resistance but in these cases benefit of flavone compounds was most marked. When given before 600-800 r X-irrad. of mice, peroral administration of rutin, hesperidin-methyl-chalcone, alphliol, quercitol, and naringoside exerted a slightly favorable effect on mortality.

PATT, H. M., M. N. SWIFT, & E. B. TYREE. Effect of rutin on the X-irradiation syndrome. AECD-2024G, 1947. ANL-4078:60-63, 1947. 466.

Administration of rutin (10 mg/kg i.p. in 5% ethanol) to 2 days before and after 550 r w.b. X-irrad. did not improve response. Data on X-irrad. of rats (650 and 700 r) were inconclusive. Dose was 50 mg/kg i.p. 10 days before and 15 days after exposure.

REKERS, P. E. & J. B. FIELD. Control of hemorrhagic syndrome and reduction in X-radiation mortality with a flavone. Science 107:16-17, 1948. 467.

Peroral administration to dogs of rutin, 50 mg, 3 times daily for 1 week before and 28 days after w.b. exposure to 350 r X-irrad. decreased mortality from 64% to 12%. Treated animals were relatively free from petechiae and ecchymosis but there were no differences in blood formed elements.

SOKOLOFF, B. T., W. H. EDDY, & G. CONE. Effect of bioflavonoids on radiosensitivity of transplanted tumors. Effect on tolerance to contact radiation. Arch. Path. 54:197-203, 1952. 468.

Rats bearing either sarcoma 39 or Crocker sarcoma were given 200 mg per 100 g of a citrus flavonoid mixture (containing hesperidine-chalcone, glucose, eriodictyol, and a quercitrin-like compound). When given before doses up to 15000 r of contact radiation, the sensitivity of the tumor was not decreased but rats were protected from radiation injury. Only slight protection was exerted by administration after irrad.

SOKOLOFF, B. T., W. H. EDDY, & J. B. REDD. The biological activity of a flavonoid (vitamin P compound). J. Clin. Invest. 30:395-400, 1951. 469.

Flavonoid (citrus-waste product) gave considerable but not complete protection to rats against near-lethal, w.b. X-irrad. Less erythema was seen in patients undergoing deep alpha-ray therapy when 300-600 mg/day was given perorally before and during treatment.

SOKOLOFF, B. T., J. B. REDD, & R. DUTCHER. Capillary fragility and vitamin P protection against irradiation. Proc. Soc. Exp. Biol. Med. 75:6-9, 1950. 470.

Injury to capillary wall caused by exposure to ionizing radiation, leukotoxine or a bacterial polysaccharide can be prevented to a considerable degree by administration of citrus flavonoids.

SOKOLOFF, B. T., J. B. REDD, & R. DUTCHER. Vitamin P protection against radiation. J. Florida Acad. Sci. 12:185-89, 1949. Science 112: 112-13, 1950. 471.

Rats were exposed to 800 r irrad. Mortality among untreated controls was 80%; administration of 4 mg of vit. P per day for 3 days before and 7 days after irrad. reduced mortality to 40%. When the flavonoid dose was increased to 5 mg daily and given 7 days before and 23 days after irrad., mortality was 10%.

XXII. VITAMIN A AND CAROTENE

A. CLINICAL STUDIES
none

B. LABORATORY STUDIES
none

C. TISSUE LEVELS AND EXCRETION

See also no. 488.

ERSHOFF, B. H. Effects of vitamin A malnutrition on resistance to stress. Proc. Soc. Exp. Biol. Med. 79:580-84, 1952. 472.

Vit. A deficiency increases sensitivity of rats to X-irrad. and to cold.

ERSHOFF, B. H. & S. M. GREENBERG. Effects of a transient vitamin A deficiency on survival following X-irradiation. Exp. Med. Surg. 11:46-48, 1953. 473.

A transient deficiency of vit. A, apparently corrected by the administration of relatively high doses of vit. A natural esters from soupfin sharkliver oil, significantly reduced the survival time of rats after a single lethal dose of w.b. X-irrad.

XXIII. VITAMIN D

See 488.

XXIV. VITAMIN E (TOCOPHEROL)

A. CLINICAL STUDIES
none

B. LABORATORY STUDIES

See also nos. 398, 488.

AMES, S. R., J. G. BAXTER, & J. Q. GRIFFITH, JR. Prevention by d-alpha-tocopherol of increased capillary fragility in rats following irradiation. Intern. Zschr. Vitaminforsch. 22:401-07, 1951. 474.

Rats were injected (i.p.) with 1 cc of 200 microcuries/cc Rn ointment. Groups of 10 were untreated or received by injection daily 0.11 cc concentrate containing 34.6% total tocopherols of which 61% was alpha or 0.55 cc of concentrate containing 72.4% total tocopherols which were half gamma and half delta. After 15 days, capillary fragility was determined and protective effects of both treatments recorded. Sterile abcesses were found at point of injection of concentrate. Adult rats were given 0.5 cc of 80 μc per cc Rn ointment and treated perorally with 2.5 or 10 mg daily of alpha-tocopherol in olive oil. Incidence of increased capillary fragility was reduced and the lower dose was more effective than the higher.

ERSHOFF, B. H. & C. W. STEERS, JR. Antioxidants and survival time of mice exposed to multiple sub-lethal doses of X-irradiation. Proc. Soc. Exp. Biol. Med. 104:274-76, 1960. 475.

Experiments were conducted to determine effects of antioxidants on survival time of mice exposed to multiple sub-lethal doses of X-irrad. Mixed tocopherols and santoquin at 0.25% level in the diet, and DPPD at levels of 0.25% or 5% of diet had little, if any, protective effect. Propyl gallate, DBH and BHT at levels of 0.25% or 0.5% of the diet increased survival over that on basal unsupplemented ration.

FURTH, F. W., M. P. COULTER, & J. W. HOWLAND. Failure of alpha-tocopherol to protect against radiation injury in rat. UR-152, 1951. 476.

Rats fed Fox Chow were given 10-12 mg of alpha-tocopherol orally, daily for 2 days before, on the day of irrad. (700 r, X-ray), and the day after. There were no beneficial effects.

HALEY, T. J., E. F. McCULLOH, & W. G. McCORMICK. Influence of water soluble vitamin E on survival time in radiated mice. Science 119: 126-27, 1954. 477.

The injection of water-soluble vit. E (25.5% alpha-tocopherol) in daily doses of 0.5, 1.0, 2.0, and 3.10 mg/animal prior to and throughout the post-irrad. period did not benefit mice receiving 550 r acute w.b. X-irrad. The two higher doses significantly decreased both the ST_{50} day and the day of total mortality indicating that these doses acted synergistically with the irrad.

HERVE, A. & Z. M. BACQ. Sulfocyanate, tocopherol, and X-rays. Compt. Rend. Soc. Biol. Paris 143:1158-59, 1949. 478.

Mice were pre-treated with two 10 mg i.v. injections of alpha-tocopherol at 24 hr intervals prior to 400 r X-irrad. Mortality of treated group was 30% versus 60% in the controls.

C. TISSUE LEVELS AND EXCRETION

See 352.

XXV. VITAMIN K (NAPTHOQUINONES, SYNKAVIT)

A. CLINICAL STUDIES

See also no. 486.

MITCHELL, J. S. Clinical assessment of tetrasodium 2-methyl-1, 4-naphthohydroquinone diphosphate as a radiosensitizer in the radiotherapy of malignant tumors. Brit. J. Cancer 7:313-28, 1953. 479.

Compound had small but useful effect as a clinical radiosensitizer, particularly when given i.v. as opposed to intramuscularly.

B. LABORATORY STUDIES

See also nos. 319, 395.

ALLEN, J. G., M. SANDERSON, M. MILHAM, A. KIRSCHON, & L. O. JACOBSON. Heparinemia (?). Anticoagulant in blood of dogs with hemorrhagic tendency after total-body exposures to roentgen rays. J. Exp. Med. 87:71-76, 1948. 480.

In dogs subjected to 450 r w.b. X-irrad. vit. K and C treatments were ineffective in the hemorrhage stage. Administration of protamine sulfate and toluidin blue restored normal clotting time.

ELLINGER, F. Pharmacological studies on irradiated animals. Part v. The effects of post-irradiation administration of vitamin K on X-ray induced mortality. Naval Medical Research Institute, Research Report, 14:55-64, 1956. 481.

Post-irrad. treatment of guinea pigs by vit. K injection, starting on day zero shortly after irrad. and extending to the 5th post-irrad. day, resulted in reduction of the $LD_{35/15}$ to $LD_{6/15}$ and of the $LD_{73/15}$ to $LD_{43/15}$. There was no significant reduction in the mortality of the $LD_{97/15}$.

FRIEDMANN, E. & N. T. J. BAILEY. Action of 1:4 naphthohydroquinone-diphosphate and its 2-methyl derivative on irradiated rats with Jensen sarcoma. Biochem. Biophys. Acta 6:274-82, 1950. 482.

Neither compound has significant effect on growth of non-irradiated sarcoma in rats. The 1,4-naphthohydroquinone-diphosphate appears to inhibit partially the action of X-rays in 40% of the cases.

IRIE, H. The clinical value of protective and pharmacological agents in radiation injury. Strahlentherapie 110:456-61, 1959. 483.

Vit. K, adenochrome and methionine combined with vit. B_{12} were effective given after 700 r X-irrad. D, L-trans-(or cis)-2-aminocyclohexanthiol were very effective.

JOLLES, B. & J. O. LAWS. The effect of Synkavit administration combined with irradiation upon rabbits and rats. Brit. J. Cancer 8:513-21, 1954. 484.

In rabbits, Synkavit (2-methyl-1, 4-naphthoquinone diphosphoric acid ester tetrasodium salt) 10-50 mg daily, administered prior to and after X-irrad. (600-1500r) slightly increased tolerance. In rats, Synkavit was detrimental.

KOHN, H. I. & S. E. GUNTER. Effect of menadial diphosphate (Synkavit) on the sensitivity of E.coli and S. cerevisiae to X-rays. Radiation Res. 2:351-53, 1955. 485.

Tetrasodium salt of 2-methyl-1, 4-naphthoquinone diphosphate did not affect the sensitivity of cells to X-irrad.

MITCHELL, J. S. Laboratory studies and clinical trials of some chemical radiosensitizers. Radiobiology Symposium, Proc. Liege, Aug-Sept, 1954: 170-89, 1955. Acta Radiol. Stockh. Suppl. 116:431-40, 1954. 486.

Both 2-methyl-and 2, 3-dimethyl-1, 4-napthohydroquinone diphosphate significantly sensitized tumors when given i.v.

MITCHELL, J. S. & I. SIMON-REUSS. Combination of some effects of X-radiation and a synthetic vitamin K substitute. Nature 160:98-99, 1947. 487.

Embryonic chick tissues were irrad. with or without pre-treatment with tetrasodium 2-methyl-1, 4- naphthoquinone diphosphate. Treatment with the compound increased tissue sensitivity to radiation.

XXVI. FOODS, CRUDE MATERIALS, MISC.

A. FOOD MIXTURES, GENERAL

See also nos. 60, 118, 134, 135, 269, 493, 494, 509.

PARIS, R. & J. VAVASSEUR. Influence of some dietetic factors on the mortality of mice due to X-ray. Therapie 8:57-61, 1953. 488.

Mice fed a diet of (parts by weight): wheat flour, 9.0; yeast, 2.5; cod liver oil, 1.0; NaCl 1.5; and Ca lactate, 5.0, with "some" milk and carrots survived 212 hr average following 600 hr X-irrad. Addition of red gooseberries, cassis, Rosa canina, orange, lemon, and Ampelopsis tricuspidate fruits for 2 weeks before irrad. yielded increased survival times of 488, 296, 218, 236, 229, and 242 hr. respectively, but unripe rose hips, orange peels and cassis leaves diminished survival time. Vit. A,D,E,B_1,B_6, and niacin had no effect. High doses of cod liver oil and wheat germ oil shortened survival. Rutin and its derivatives (mg/day/mouse) increased survival time to over 240 hr even after 700 r irrad.

PEREPELKIN, S. R. & G. I. BOUDOREV. The protective role of food in acute radiation affection on the organism. Med. Radiol. 4:no. 12, 53-58, 1959. 489.

A large survival rate (after 600 r X-irrad.) was achieved with animals kept on a milk-egg diet, much lower survival rate with low animal protein diets, "physiological" milk-egg diets were intermediate. Enrichment with vit. C. P, and B complex (B_1, B_2, PP, B_6, and folic acid) led to a considerable rise in protection, especially effective when the meat and physiological diets were given. Three doses of vit. enrichment were given: large, low, and large with altered vit. balance (decrease in C, P, PP, increase of the others). The large dose was much more effective than the other two.

PEREPELKIN, S. R. Experimental data on a convalescent-preventive diet during radiation sickness. Trudy Vsesoyuz. Konf. Med. Radiol. 62-67, 1957. 490.

A diet containing proteins of milk (37%), eggs (14%), and meat (20%); a milk diet with proteins of milk (52%) and meat (20%); a liver diet with proteins of liver (50%) and meat (20%); a meat diet with 69% of the protein from meat; and a "normal" diet with 62% of the protein from meat and 8% from milk were used on rats irrad. at doses of 550 and 500 r. The improvement in survival rate was 30% for the meat diet, 42.5% for the liver diet, and 45% for the milk-egg diet at a dose of 500 r. By enriching the respective diets with vit. PP, P, and C, the survivals were 23% for the meat diet, 46% for the liver diet, and 54% for the milk-egg diet. The number of survivals of dogs irrad. at 350 and 400 r was 56.2% for the normal diet, 55.5% for the liver diet, and 68.7% for the milk-egg diet. By enriching the diet with vit. PP, P, and C (10 mg/kg) the survival rate was increased (7 out of 9 dogs on the milk-egg diet survived at a dose of 400 r). Two dogs were put on a milk-egg diet and a meat diet, respectively, for 10 days and then inoculated with 0.5 μc Sr^{90}/kg. The dog on the milk-egg diet eliminated 76.5% of the Sr^{90} in 24 days and survived, while the dog on the meat diet eliminated only 21% of the Sr^{90} and perished on the 23d day.

SHATERNIKOV, V. A. Effects of various dietary factors on the absorption processes of small intestines in animals exposed to damaging radiation. Med. Radiol. 1: no. 4, 61-67, 1956. 491.

Dogs with Tiery fistulae were fed: a) "Physiological" ration containing 70% calories from protein-meat 62%, milk 8%; or b) "liver" ration, 70% protein calories-50% from liver, 20% meat, and subjected to acute or sub-acute doses of radiation. Absorption of glycocoll (glycine) was decreased after irrad. Normalizing effects on absorption resulted from substituting a "milk-egg" ration (milk 37%, egg 14%, meat 20%) and enrichment of the "physiological" or "milk-egg" rations with vit. P (12.0 mg/kg) or C (10 mg/kg) or nicotinic acid (10 mg/kg).

B. GREEN PLANT MATERIALS

See also nos. 273, 465.

CALLOWAY, D. H., A. H. MUNSON, & R. HILF. Effects of X-irradiation of guinea pigs fed a basal diet of bran and oats, with or without raw broccoli. QM Food & Cont. Inst. for the Armed Forces., QMFCIAF Rpt. 37-60, 1960. 492.

Young male guinea pigs were fed a basal diet of bran and oats, with or without a daily exposure to 400 r w.b. X-irradiation. Animals were killed sequentially for histologic and hematologic examination. Provision of broccoli resulted in improved nutriture, larger livers with higher stores of vit. A and minimal fatty changes, and superior gonadal development. Following irrad. in both groups, decrements in body weight and food intake as well as the characteristic events of the radiation syndrome were seen. Broccoli supplementation of the cereal diet generally reduced the degree of distortion or delayed its appearance.

CALLOWAY, D. H., A. H. MUNSON, & H. SPECTOR. Response of rats fed various diets to acute X-irradiation. QM Food & Cont. Inst. for the Armed Forces, QMFCIAF Rpt. 38-60, 1960. 493.

Rats were fed a variety of basal diets and supplements for 2 weeks before and 30 days after w.b. exposure to single doses of 700 to 1000 r of X-irrad. No consistent superiority of any dietary treatment was seen using survival as the criterion. There was a tendency toward prolonged survival time in the presence of high vit. levels and raw Brassicaceous vegetables. Scattered data on enzyme activities, morphologic characteristics and reproductive performance did not clearly differentiate diet groups.

DARBY, W. J. Protective effects of certain natural foods against whole-body irradiation. QMFCIAF Contract N-1130, Prog. Rpt. 1, 1959. AD-219-978. 494.

Dietary supplementation with green plant materials is under study. Final report will be available in 1961.

DUPLAN, J. F. Influence of dietary regime on the radiosensitivity of the guinea pig. Compt. Rend. Acad. Sci. Paris, 236:424-26, 1953. 495.

Guinea pigs fed a basal diet of bran and oats together with green cabbage or carrots were exposed to 300, 500, or 1000 r of X-irrad. Cabbage reduced mortality and body weight loss. No data are given in support of statement that, "If bran and oats are replaced by a balanced synthetic diet the results are identical."

LARTIGUE (GALLIEN), O. Modifications caused by X-irradiation in the lipids and several other constituents of the liver of the guinea pig. Thesis, Faculte des Sciences de l'Universite de Paris, 1959. 496.

Guinea pigs fed a basal diet of bran and oats were given: I. dietary supplements of cabbage (C) or beets (B). Among non-irrad. animals, liver concentration of glycogen was higher and cholesterol lower in C than in B. Over a 72 hr period of fasting C lost less body weight than B and showed an increase in liver total fat. Survival after w.b. X-irrad. was greater in C, than B but similar changes in liver composition were noted from doses of equal lethality (B 375 r; C 800 r) (large livers high in water and fat, low in glycogen). C animals were also more resistant to accumulative doses of X-irrad. (100 r per week). Improved performance of C may be attributable to functional changes in pituitary-adrenal axis; a hypothesis based on indirect evidence. II. Added supplementation with choline Cl, 100 mg per day 1 week before and continuing after X-irrad. (B 375 r; C 800 r) was detrimental in terms of survival and induced hepatic centrolobular necrosis not seen in unsupplemented groups.

LOURAU, M. & O. LARTIGUE (GALLIEN). Influence of dietary regime on the biological effects produced by a single whole-body irradiation (X-rays). Experientia 6:25-26, 1949. 497.

Supplementation of a bran-oats diet with cabbage results in improved radioresistance in the guinea pig, as compared with a supplement of beets.

MUNSON, A. H. & D. H. CALLOWAY. Absence of radioprotection in cabbage-fed swine. QM Food & Cont. Inst. for the Armed Forces. QMFCIAF Rpt. 29-60, 1960. 498.

Eighty-two swine were exposed to 11 different dose levels of Co^{60} gamma-radiation. Exposures ranged from 75 to 1650 r measured in air. All animals exposed to over 525 r were divided into 2 dietary groups. Basal diet was supplemented with dehydrated cabbage in one group and dehydrated white potatoes in the other. No differences in the responses attributable to sex or diet were noted.

SPECTOR, H. & D. H. CALLOWAY. Modification of the response of guinea pigs to whole-body irradiation by dietary supplementation with raw plant materials. QM Food & Cont. Inst. for the Armed Forces. QMFCIAF Rpt. 28-60, 1960. 499.

Exposure to 400 r w.b. X-irrad. resulted in 99% mortality in 10-15 days of young male guinea pigs fed basal diet of bran and oats plus ascorbic acid. Supplementation with green plant materials, notably from the Brassicas, for 2 week before irrad. and during 30 days after irrad. reduced mortality to 46%. Other categories of foods showed marginal or no beneficial effects. Pre-feeding of cabbage to time of radiation exposure delayed onset of death; post-irrad. supplementation yielded a lower total mortality. These effects were additive. Supplements which were beneficial promoted improved growth, but superior weight gain did not guarantee decreased radiosensitivity. Supplements providing vit. A uniformly extended survival time but did not consistently influence mortality.

SPECTOR, H. & D. H. CALLOWAY. Reduction of X-radiation mortality by cabbage and broccoli. Proc. Soc. Exp. Biol. Med. 100:405-07, 1959. 500.

Exposure to 400 r of w.b. X-irrad. resulted in 100% mortality in 10 to 15 days of young male guinea pigs fed a basal diet of bran and oats plus ascorbic acid. Supplementation with cabbage or broccoli for 2 weeks before irrad. and during 30 days after irrad. significantly reduced mortality. Lyophilized cabbage retained ability to reduce radiation mortality. Pre-feeding of guinea pigs to time of radiation exposure significantly delayed onset of death and enabled some animals to survive the test period. Post-irrad. supplementation with cabbage also yielded a lower total mortality. Feeding of cabbage both before and after radiation exposure produced greatest amount of protection.

TSUKAMOTO, R. Metabolic disturbances after roentgen irradiation of the liver. Strahlentherapie 18:320-68, 1924. 501.

Blood sugar and nitrogen levels in rabbits subjected to irrad. of the liver are said to be related to the carbohydrate content of the diet. Drop in blood sugar following irrad. was minimized by force feeding or by providing foods higher in carbohydrate (cereals vs. beets vs. cabbage).

C. LIVER

See also nos. 60, 223, 230, 344, 352, 493.

ANON. Diet and X-irradiation. Nutrition Rev. 11:13-14, 1953. 502.

A review of Ershoff's work on liver feeding.

BRUDIGAM, B. & H. BRAUN. Clinical and experimental animal studies of the effects of liver hydrolysates on radio-induced reactions. Strahlentherapie 112:621-28, 1960. 503.

Favorable effects were seen including maintenance of more nearly normal serum albumin and enzyme levels.

ERSHOFF, B. H. Increased survival of liver-fed rats administered multiple sub-lethal doses of X-irradiation. J. Nutrition 47:289-98, 1952. 504.

Dietary supplementation with liver powder was beneficial to rats given multiple sub-lethal doses of X-irrad. but not to those given a single lethal dose. The protective factor is distinct from the B vit.

ERSHOFF, B. H. Protective effects of liver residue on rats administered multiple sub-lethal doses of X-irradiation. Exp. Med. Surg. 12: 361-66, 1954. 505.

Water-insoluble residue fraction of dessicated liver is active in prolonging survival of rats to multiple sub-lethal doses of X-irrad.

MacNider, WM. deB. The inability of vitamin B complex as liver extract to protect the kidney against the toxic action of uranium nitrate. J. Pharmacol. Exp. Therap. 88:323-26, 1946. 506.

Twelve dogs were given 3 mg uranium nitrate/kg by subcutaneous injection. Half were treated with 0.25 cc liver extract (intramuscular injection) every other day for 12 injections before uranium administration and throughout the remainder of experiment. No differences due to treatment were seen.

OGANEZOVA, A. A. The character of changes of correlations of serum proteins of the blood of rats in X-ray irradiation against a background of varying diet. Voprosy Pitania 17: no.3, 38-43, 1958. 507.

Rats were fed 3-4 weeks before and 1-2 months after 500 and 600r X-irrad. a control casein diet or the diet with 10% dried beef liver added. Serum protein changes (decreased albumin and increased alpha, beta, and gamma globulin) were minimized in the liver-fed group.

OGANEZOVA, A. A. The effect of different nutrition on the character of changes of the blood protein-fractions under the action of X-rays. VoprosyPitania 18: no. 2, 49-55, 1959. 508.

Adult rats were fed 3-4 weeks before and 30 days after single w.b. X-irrad. (500-600 r) these diets: I. Control, 18% casein; II, 10% dessicated beef liver in lieu of equal weight casein; III, Control and 10% dessicated liver (25% protein); IV, 25% casein. Poorest performance, in terms of changes in serum protein, leukopenia, body weight, and mortality, was seen with I; best with III. Mortality was 80% with I, 25% with III. Values for serum proteins are given.

ZIPORIN, Z.Z., J. A. TILLOTSON, R. SOLKOT, J. W. NEEDHAM, & A. J. BAUER. The effect of dietary supplements on the survival of irradiated rats. U. S. Army Med. Res. and Nutr. Lab., Rpt. 230, 1959. 509.

There was no difference in weight gain of rats given 725 r w.b. X-irrad., attributable to supplementation of a synthetic diet with streptomycin. Survival of rats given 750 r of X-irrad. in a single dose was slightly but not significantly greater on a laboratory chow diet than on a synthetic but supplementation with liver or S was without effect.

D. YEAST AND NUCLEIC ACIDS

See also no. 493.

DETRE, K. D. & S. C. FINCH. Radiation protective effects of yeast extract and yeast ribonucleic acid. Science 128:656-57, 1958. 510.

Crude yeast antolyzate, injected i. p. or i. v., within 15 to 30 min prior to 900 r w.b. X-irrad. to rats and 700 r to mice, prolongs survival times. Commercial preparations of yeast ribonucleic acid are protective also. The protective action of yeast antolyzate may also be due to ribonucleic acid.

KARPFEL, Z., J. SOSKA, & N. F. BARAKINE. Study of regeneration processes in the bone marrow of irradiated mice following the administration of pyrimidine deoxyribonucleotides. Folia Biol. (Prague), 6: 179-85, 1960. 511.

Desoxycytidylic or thymidylic acid was administered to mice irrad. with a dose of 500 to 600 r. After administration of these desoxynucleotides an increase in mitotic activity was observed in the bone marrow, together with stimulation of regeneration. The least mature cell forms in the bone marrow reacted most promptly to the administration of thymidylic acid by proliferation. After the administration of the desoxyribonucleotide, rather more chromosomal aberrations were found than in the irrad. control. Irrad. significantly lowered the prophase to metaphase ratio. This ratio returned to normal 4 to 10 days after irrad., recovery being significantly more rapid after the administration of the desoxynucleotide than in the irrad. control.

LUCHNIK, N. V. The effect of yeast extracts on irradiated organisms. Biokhimia 23. no.1, 146-53, 1958. (Engl. tr.) 23:146-48, 1958. 512.

In mice i.p. injection of 0.3 of yeast extract increased LD_{50} by about 100 r. Details of preparatory methods for effective extracts are given. Effectiveness is correlated with P content and RNA has same effect as extract although not all RNA preparations are active.

MAISIN, J. R., P. DUMONT, & A. DUNJIC. Further study of the influence of yeast nucleic acid on the thirty day survival of rats after whole-body X-irradiation. Compt. Rend. Soc. Biol. Paris, 154: 429-32, 1960. 513.

Yeast nucleic acid substantially increased the percentage of 30 day survivors if injected i.p. within 15 min after exposure to 500 r.

MAISIN, J. R., P. DUMONT, & A. DUNJIC. Influence of injections of alkaline hydrolyzates of yeast nucleic acid on thirty day survival of rats irradiated with 500 r. Compt. Rend. Soc. Biol., Paris, 154; 475-79, 1960. 513a.

I.p. injection of hydrolyzate 15 min after X-irrad. increased 30 day survival as much or more than yeast nucleic acid. For best results the alkaline hydrolysis should be carried out just to the mononucleotide stage.

MAISIN, J. R., P. DUMONT, & A. DUNJIC. Yeast ribonucleic acid and its nucleotides as recovery factors in rats receiving an acute whole-body dose of X-rays. Nature 186:487, 1960. 514.

MAISIN, J. R., A. DUNJIC, P. MALDAGUE, & L. DECKERS PASSAU. Protective action of ribonucleic acid and sodium ribonucleinate in white rats irradiated in toto. Compt. Rend. Soc. Biol. Paris, 153: 379-81, 1959. 515.

A suspension of 100 mg of ribonucleic acid or its Na salt injected i.p. 15 min before a lethal w.b. X-irrad. (500 r, causing death between 7 and 30 days) saved 60% from death and protected against bone marrow damage.

PABST, H. W. & C. STROHM. Radiation protective effects of yeast concentrate. Strahlentherapie, 113:286-98, 1960. 516

Survival rate of mice following lethal doses of w.b. X-irrad. were increased 20-25% by oral or i.p. treatment with yeast preparations. Studies on 120 patients showed a favorable effect of oral administration of concentrated yeast on red blood count of X-irrad. patients and patients treated with radioisotopes.

PALECEK, E. & J. SOSKA. Effect of ionizing radiation on deoxyribonucleic acids. ii. The molar relationship of deoxyribonucleic acid bases of rat speen after the administration of pyrimidine deoxyribotides. Folia. Biol. (Prague), 6:168-71, 1960. 517.

Desoxycytidylic acid or thymidylic acid was administered i.p. to rats one day after they had been irrad. with a w.b. dose of 400 r. On the 5th day after irrad. the animals were killed and the ratio of the bases was determined in DNA isolated from the spleen. In rats to which desoxycytidylic acid was administered, the guanine/cytosine quotient and the adenine/thymine quotient were lower than in the irrad. controls After the administration of thymidylic acid only the guanine/cytosine quotient was reduced. In no group, however, did all base relationships return to normal values.

PANJEVAC, B. & G. RISTIE. Recovery from radiation injury in rats following administration of rat isologous highly polymerized nucleic acids. Bull. Inst. Nuclear Sci. "Boris Kidrich" (Belgrade) 8: 159-60, 1958. 518.

A single w.b. exposure of 700 to 750 r was given to rats (16 weeks) separated into groups of 10. The groups were injected with highly polymerized DNA and RNA as well as rat bone-marrow suspension. 30% of the rats treated with isologous RNA were alive 30 days after irrad. The control irrad. rats were dead by the 14th day. The DNA and RNA content of the treated animals increased 27% and 52%, respectively, and was accompanied by an increase in body weight. The homologous RNA had a lower protective effect and the highly polymerized isologous DNA as well as the bone-marrow suspensions were less effective than isologous RNA in affording protection against radiation death.

PATT, H. M., E. M. JACKSON, & J. H. POMEROY. "Pentoxyl" and radiation neutropenia. Radiation Res. 12:461-62, 1960. 518a.

Negative when given 15 days post 750 r irrad. in rabbits as 65 mg of 5-hydroxymethyl-6-methyluracil, daily by subcutaneous injection.

RASKOVA, G., D. SKROBAL, & A. DINSTBIR. Detoxicating effect of ATP (adenosinetriphosphoric acid). Physiol. Bohemosloven 5:444-47, 1956. 519.

Rats exposed to X-irrad. of 400-810 r were treated with ATP starting on the 5th day after irrad. It is shown statistically that the mortality rate of ATP-treated animals is significantly lower than that of untreated animals.

SMITH, W.W., H. J. RUTH, & H. Y. CANTER. Failure of reticulose to reduce radiation lethality in mice and rats. Proc. Soc. Exp. Biol. Med. 81:116-18, 1952. 520.

Reticulose (a lipoprotein-nucleic acid complex) given subcutaneously to mice, with or without streptomycin treatment, failed to alter mortality, leukocyte count, or incidence of septicemia after 625 r w.b. X-irrad. In rats it failed to alter mortality after 570 r w.b. X-irrad.

SOSKA, J. & Z. KARPFEL. Comparison of the effect of some nucleotides and nucleosides on the mitotic index in the bone marrow of irradiated mice. Folia Biol. (Prague) 6:172-78, 1960. 521.

Results are reported from a study of the effect of different nucleotides and nucleosides on the bone marrow of mice irrad. with a dose of 500 to 600 r. The effect of riboside and desoxyriboside and of nucleotide and nucleoside derivatives of adenine, guanine, uracil, and thymine was compared. The mitotic index, which was lowered by radiation, was significantly raised on about the 6th day after irrad. following the administration of desoxycytidylic, thymidylic, and desoxyadenylic acid. A less marked effect was observed after thymidine, desoxyadenosine, and cytidylic acid. Desoxyguanylic acid lowered the mitotic index. The other test substances had no effect.

THOMPSON, R. M. A lipo-protein-nucleic acid complex in the treatment of radiation injury: A preliminary report. Military Surg. 110: 51-59, 1952. 522.

From a pilot experiment in the treatment of post-irrad. injury, it is believed that non-specific protein therapy in the form of lipoprotein, nucleic acid complex (Reticulose) is of value.

E. ETHYL ALCOHOL (ETHANOL)

COLE, L. J. & M. E. ELLIS. Decreased X-ray sensitivity of mice following administration of ethanol. USN Radiol. Def. Lab. USNRDL-341, 1952. J. Physiol. 170:724-30, 1952. 523.

3.75 ml of 25% ethanol (per 100 g) was administered i.p. to mice before w.b. X-irrad. (750 and 850 r). Survival was improved and LD_{50} increased from 620 r to 814 r. No protection was seen in rats given comparable treatments.

HONDA, MIYOHIKO. The effect of some protective agents on irradiated animals. (An experimental study.) (Abstr.) Nagasaki Med. J. 35:60-61, 1960 524.

Before X-irrad. 0.5 ml ethanol (10%) or 25 mg S-aminocaproic acid (Ipsilon)/20 g were given to white mice; with ethanol, 75% with "Ipsilon", 50% survived, while all controls died. After i.p. injections of ethanol (10%, 20 cm^3/kg) to rabbits given 500 r w.b. irrad., no significant difference between protected and control animals was found relative to radio-induced leukopenia, except for more rapid recovery.

LOMONOS, P. I. Summaries of reports at the administrative plenum of the All-Union Society of Roentgenologists and Radiologists, U.S.S.R. June 1952. 525.

Alcohol treatment was ineffective in rats. (not seen).

LUCHNIK, N. V. Alcohol and the biological effects of ionizing radiation. Soviet J. Atomic Energy 5:134-35, 1956. J. Nuclear Energy 5:163-65, 1957. 526.

Ethyl alcohol (50-200 mg per animal administered i.p.) given to mice before 500-700 r w.b. exposure to Co^{60} radiation diminished 30-day mortality.

NEVERMANN, H. The treatment of general X-radiation injuries. Klin. Wochschr. 2:1747-48, 1923. 527.

Beneficial effects in prevention of radiation sickness were obtained by sodium chloride per os or i.v., by cognac, and by "Aolan" injections.

PATERSON, E., J. J. MATTHEWS. Protective action of ethyl alcohol on irradiated mice. Nature 168:1126-27, 1951. 528.

Mice 6 to 8 weeks old were given two 1-ml doses orally of ethyl alcohol (10% by volume in saline) 80 and 20 min before 700 r X-irrad. Mortality was 63% compared with 100% for controls. A rise in the LD_{50} radiation dose from 554 to 625 r and an extension of the life of non-survivors were noted with the alcohol treatment. No protection was obtained when the alcohol was given after irrad. The difference in protective value between 5 and 10% alcohol was not significant. I.v. cysteine, 20 mg/mouse, gave greater protective effect than alcohol in the doses used. Protection by alcohol was unrelated to its anesthetic effect. I.v. nembutal, 1.3 mg/mouse, and i.p. ethyl carbamate, 20 mg/mouse, did not change the LD_{50}.

PATT, H. M., S. MAYER, & D. E. SMITH. Modification of radiation responses in mammals by chemical factors. ANL-4625, 1951. 529.

Ethanol (10%, 1 cc, i.v.) appears to modify survival of mice appreciably when given immediately before but not after irrad. 10% ethanol in the drinking water for one week prior to irrad. is ineffectual.

F. MISCELLANEOUS

See also nos. 234, 343, 475.

BEZZABOV, A. D. Food for people working with radioactive isotopes. U.S.S.R. Patent 104,801, 25 Feb 1957. 530.

Pectinous substances having free carboxylic groups are incorporated in the food for people working with radioactive isotopes of bi- and multi-valent metals, for the purpose of inactivating the isotopes. One embodiment of this food is rock candy into which were incorporated pectinous substances having free carboxylic groups.

BREKHAMM, I. I., L. I. OSKOTSKII, & A. K. KHAKHAM. The effect of certain preparations from the Aralia family of plants in experimental radiation sickness. Med. Radiol. 5: no. 2, 33-36, 1960. JPRS-5078:77-84. 531.

In ginseng therapy of irrad. mice (400 r), the survival was 2½ times higher, and in Eleutherococcus treatment the survival was almost 5 times higher as compared with the control group. In the combined action of X-ray and overloading (rotation of mice for 5 sec in a centrifuge at 400-500 rds/min) the therapeutic effect of ginseng and Eleutherococcus was even more pronounced than if only X-rays were used.

FORSSBERG, A., Ch. LINGEN., L. ERNSTER, & O. LINDBERG. Modification of the X-irradiation syndrome by lycopene. Exp. Cell. Res. 16: 7-14, 1959. 532.

I.p. administration of lycopene as particulate suspension has moderate curative action given before and also shortly after X-irrad.

FORSSBERG, A. and others. Investigation of the curative effect of lycopene in irradiated mice. Acta Radiol. Stockholm 53:392-400, 1960. 533.

The action of lycopene administered after irrad. was investigated in a large series of mice. Some of the experiments showed that results were improved by an initial dose of polyphloretin phosphate i.p. 24 hr before irrad. A possible increase in adrenal function in the treated animals was observed.

GIORDANO, A., A. TRENTA, & L. MAZZA. Investigation of the eventual radioprotective effect of royal jelly in the rat. Radiobiol. Radiotherap. Fiz. Med. (3) 14:423-39, 1959. 534.

Mus musculus L. received 600 r X-irrad. Those that were given royal jelly in addition to the usual diet, showed significant radioprotection by prolongation of average life, less damage to the hemopoietic system and, in particular, only reversible alterations to the liver and spleen occurred.

LACKNER, J. Treatment of radiation intoxication with "Rokan." Strahlentherapie 89:283-87, 1952. 535.

Tablets called "Rokan" are a combination of Nux vomica D4 with special extract of oats and other Gramineae, with special consideration of some vit. containing components. As with many other plant extracts the exact chemical content of these vit. is not known. The preparation was very effective with 80 patients and without any bad effects.

MOVSESYAN, M. A., S. G. SHCHUKURYAN, & A. YE. AGABABYAN. Concerning the reflex mechanism of the effect of X-rays. Akad. Nauk. Armian. SSR, Erivan, Izv. Biol. Sel'skokh. nauk. 9: no.3, 149-56, 1956.536.

Irrad. (100 r) of the hepatic region of rabbits causes increased blood sugar and changed white cell patterns. These changes are not apparent when caffeine is administered.

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