~~SECRET~~

NM 006 012

Medical Defensive Aspects of Atomic Warfare

2/15/50

AT 06601

Naval Medicine

Atomic Medicine

BuMed (Code 74)

Naval Medical Research Institute
Bethesda, Md.

BuMed

NMRI

Contg

As indicated in Subtasks

xxxxxxx Revised 2/15/50

1A

50 225.M
51 250.M

Superseded Report NM 006 012 dated 9/22/49

The atomic bomb causes harmful effects to personnel in the form of blast, thermal and ionizing radiation injuries. In order to develop methods of prevention and treatment, it is necessary to study the physical forces involved as well as the nature of the injuries.

(a) The objectives of this project are given as follows in accordance with the four sub-tasks under which the research work is being conducted.

(b) The approach to the problems is indicated by the following subtasks which detail the individual studies underway at present directed toward solution of the project.

(c) Subtasks:

NM 006012.01 Blast Studies. The objective of this study is to develop equipment for simulating the atomic bomb air blast and to study the nature of direct air blast injuries in animals with reference to peak pressure and wave form.

Much experimental work has been done on direct air blast injuries in animals produced by high explosives. Also, the bombings of the last war have provided opportunity for the observation of air blast effects in the human. Apparently a peak pressure of around 175 Psi are required to cause fatal lung hemorrhage in man. For small animals this peak pressure is much less, about 35 Psi for rats and mice.

There is some evidence from the Bikini experiments that direct air blast injuries occurred at a lower peak pressure than with high explosives. This may be due to the longer duration of the positive phase. In order to investigate this problem, a blast generator is being constructed at the Pasadena Physics Laboratory of NOTS, Inyokern, for which the amount of $10,000 has been made available by the Armed Forces Special Weapons Project.

The work of this project is to be conducted in two phases as described below. Phase 1 in now nearing completion.

26

T98 A62 BmS 519 ~~SECRET~~ 49, 42, 57

1 15

SECRET

Project Title: Medical Defensive Aspects of Atomic Warfare

(c) Subtasks (cont')

NM 006 012.01 Blast Studies (cont')

Phase 1. The design and construction of an air blast generator. The object of this phase is to design and construct an air blast generator for simulating the atomic bomb air blast. This equipment will be used to study the nature of direct air blast injury in animals with reference to peak pressure and wave form.

This blast generator consists essentially of a modified shock tube, 12 inches in diameter, with detachable lucite sections of various lengths by which arrangement of the physical characteristics of the shock wave be varied. According to calculations made, it will be possible to generate blast waves simulating both those of H.E. and the atomic bomb which has a positive phase of longer duration. According to the latest report the blast generator is ready for the first test. When completed, it will be brought to the NMRI for the second phase of the study.

Phase 2. The study of simulated atomic bomb radiation injuries in animals and man. The objective of this phase is to study the nature of simulated atomic bomb direct air blast generator for simulating atomic bomb air blast waves is under construction as phase 1 of this project. This blast generator will have a diameter of 12 inches which will permit the use of experimental animals ranging in size up to the rabbit or small dog. By using animals of various sizes as the mouse, rat, guinea pig, rabbit, etc., it will also be possible to investigate the relation of body weight to lethal peak pressure.

NM 006 012.02 Thermal Studies. The objective of this study is primarily to develop equipment for simulating atomic bomb thermal radiation and to investigate the nature of the thermal injuries in animals and man relative to prevention and treatment. Work under this study will be divided into two phases as follows:

Phase 1. The design and construction of a thermal radiation generator. The thermal radiation generator must be capable of producing a high flux of radiant thermal energy in the proper spectrum in order to be valuable as a laboratory source able to simulate atomic bomb thermal burns. In the past, several sources have been tried, including burning magnesium, high-intensity gas discharge tubes, exploding wires, and carbon arcs. The last has proved the most satisfactory source thus far. By focusing a high intensity carbon arc with suitable mirrors, a secondary focus can be produced having a thermal flux comparable to that of the atomic bomb at significant range. Using this scheme, valuable investigation work has been done at the Material Laboratory of the New York Naval Shipyard on materials, and at the University of Rochester on laboratory animals. There are on hand, at the present in the Research Institute, two 24 inch Navy searchlights, similar to those in use by the New York Naval Shipyard, by which the thermal studies are being extended to experimental animals.

(c) Subtasks (cont')

NM 006 012.02 Thermal Studies (cont')

Phase 1 (cont')

Future atomic bomb tests are expected to yield information which will enable closer approximation of laboratory sources with respect to time-intensity relations and wave-length distribution.

Phase 2. The study of simulated atomic bomb radiation injuries in animals and man.

The thermal radiation generator described in the first phase of this study will be used in the investigation of flashburns. It is planned to use laboratory animals for the greater part of the program, and human subjects mainly for correlative purposes. Young white pigs have been used by the group in Rochester, and have seemed a valuable although not ideal laboratory animal for the purpose. Investigative effort will be given initially to acquiring basic data concerning this rather specialized type of thermal injury with subsequent attempts to provide more simple prophylactic and therapeutic measures required for the mass treatment of burn casualties.

NM 006 012.04 Biological Effects of Radiation. The objective of this study is to investigate certain of the biological effects of ionizing radiation as related to the problems of ionizing radiation injury in man. The work under this study is necessarily diverse involving, pathologic, hematologic, pharmatologic, physiologic and biochemical studies.

Phase 1. Design and construction of a radiocobalt large animal irradiator. The objective of this phase is to design and construct a large animal (goats, pigs and dogs) gamma ray irradiator capable of administering a predetermined, reasonably uniform, dose of total body radiation.

Experience with a million volt industrial X-ray unit at the U. S. Naval Gun Factory, Washington, D. C., used for the determination of the MLD 50 in goats and pigs indicates that a uniformly reproducible X-ray dosage may be obtained only with great difficulty. The requirements of a wide beam of uniform high intensity of essentially monochromatic hard radiation is not readily obtained by means of an X-ray source. Furthermore, high voltage equipment requires several highly competent assistants for its operation. Since the output of an X-ray tube is not uniform with time, great care must also be used in monitoring the intensity.

The study of ionizing radiation including radiation illness demands the irradiation of a large number of experimental animals with a predetermined reproducible gamma ray dose. Subject phase contemplates the design and construction of a large animal irradiator utilizing a radioisotope as the source of 1 MEV gamma rays of administering a dose of about 500 r. per hour of total body irradiation.

Project Title: Medical Defensive Aspects of Atomic Warfare

(c) Subtasks (cont')

NM 006 012.04 Biological Effects of Radiation. (cont')

Phase 1 (cont')

Radiocobalt (Co 60) is considered to be a suitable source of gamma rays for the large animal irradiator under construction. It has a half life of 5.2 years, produces essentially monochromatic gamma rays of from 1.1 to 1.3 MEV and is readily produced in the uranium graphite pile by slow neutron irradiation of Co 59. The reaction is of the (n, gamma) type. The irradiator will consist essentially of a chamber about 40" in diameter and 5 feet long surrounded by 100 tubes containing capsules of 12 curies each of radiocobalt so distributed upon the surface of the cylinder so as to achieve the optimum in uniformity of radiation within its interior. Pneumatic means will be provided whereby the 100 capsules of radiocobalt may be removed from their respective positions upon the surface of cylinder to a shielded vault. This will permit the placement and removal of animals for irradiation.

The plans have been formulated to include adequate shielding for the protection of the operator and assistants, also automatic safety devices to prevent the injury of personnel through carelessness or ignorance. The irradiator will be housed in a shielded concrete vault designed to reduce the external radiation to at least one-half tolerance dose.

The animal irradiator will also be available to investigators in other institutions in the Washington area such as the National Cancer Institute, the National Institute of Health, Bureau of Standards and the Carnegie Institute.

Phase 2. Mathematical analysis of data from (a) atomic weapons testing, (b) lethal dose studies, and (c) factors relating animal irradiation experiments to man.

It is the objective of this phase to provide the facilities for mathematical analysis of data concerning (a) atomic weapons testing, (b) lethal dose studies and (c) biological effects of radiation where such analyses are beyond the scope of the routine statistical procedures available to the individual investigator. Emphasis will be placed on such analyses as fall within the domain of theoretical physics and on the borderline between physics and biology.

Project Title: Medical Defensive Aspects of Atomic Warfare

(c) Subtasks (cont')

NM 006 012.04 Biological Effects of Radiation (cont')

Phase 2 (cont')

Examples of work falling under this project are:

1. Preparation of Bikini reports giving the locations of the test materials in terms of distance and angle from the atomic bomb explosion, and the dosages and shielding in each case.

2. Analysis of thermal effects on animals and materials.

3. The analysis of predicted physical factors which will determine the placement of biological test materials during atomic bomb tests.

4. Calculation of dosages and shielding for the gamma ray generator under construction at the NMRI.

5. Analysis of data obtained in lethal dose studies.

6 Theoretical treatment of data found in radiological literature on radiation injury in man and animals.

Phase 3. Determination of the lethal dose of total body X-irradiation in swine.

The objective of this phase is (1) to determine the lethal dose of 2000 KV X-rays in adult swine exposed over one lateral aspect and over both lateral aspects; (2) to compare the tissue reactions produced by the two methods of exposure; (3) to compare the lethal dose curves obtained by the two methods of exposure using 1000 KV, 2000 KV and possibly 250 KV sources.

Healthy swine weighing 125-150 lb. each will be exposed in groups of 8-at-a-time at 2 meters distance from a 2000 KV and possibly 250 KV X-ray source. At the half-way point of each predetermined dose, 4 of each group of 8 swine will be turned so as to expose the opposite lateral aspect. The total dose for each group will thus be the same, but the manner of exposure will vary as indicated. The animals will be observed for a 30 day period following X-radiation. Autopsies and tissue studies will be performed on the survivors as well as on those which die during the 30 day observation period. By varying the doses of X-ray lethal dose curves (mortality curves) for the two methods of exposure will be established.

Phase 4. Study of the lymph in irradiated dogs.

The objective of this phase is to fill a gap in our knowledge of the effects of irradiation by (1) the study of the composition, rate of flow and toxicity of the lymph from the thoracic, cervical and peripheral ducts of irradiated animals, and (2) the study of alteration in capillary permeability following X-radiation.

It is proposed to subject healthy 15 to 20 kilogram male dogs to $LD_{100}/30$ days, $LD_{50}/30$ days amounts of total body X-irradiation and/or to 1000 r. doses of sectional X-irradiation at the Naval Ordnance Laboratory, White Oak, Maryland. The 2000 KV X-ray apparatus will be used in the early experiments but later the animals may be irradiated in the cobalt irradiator under construction at NMRI.

Project Title: Medical Defensive Aspects of Atomic Warfare

(c) Subtask (cont')

MM 006 01 04 Biological Effects of Radiation (cont')

Phase 4 (cont')

Cannulation of the thoracic, right cervical and peripheral lymph ducts will be performed following the well established methods of C.K. Drinker and associates. Samples of lymph will be taken before and as soon as practicable after irradiation. In instances when the study plan requires a considerable time interval between irradiation and study, cannulation will be done several days after irradiation. When the dogs cannot act as their own controls, that is, where observations on the same animal before and after irradiation proves to be not feasible, each dog will have a normal control companion which will receive identical handling except for irradiation. In one phase of the experiment the collected lymph will be analyzed for change in rate of flow, protein composition (chemical and physical means), bacterial and cellular content, clotting time, prothrombin time, protamine titratable substances and specific gravity.

In another phase of the experiment, the onset and development of increased capillary permeability in irradiated tissue will be determined. This will be accomplished by the intravenous and subcutaneous injection of radioactive iodoprotein. With the appearance of active (tagged) protein in the lymph an accurate quantitative measurement can be made of the time relationships and the degree of capillary permeability in any part of the animal body produced by total body or sectional irradiation. Radioactive iodoprotein has been successfully used by Cope and associates to determine increased capillary permeability following burns. The substance is easily prepared, has a convenient half life, is measurable in tracer amounts, is relatively non-toxic and affords a simple means of accurate quantitative measurement with the equipment available at this Institute.

A third phase of the experiment will deal with the toxicity of lymph from donor-irradiated dogs when injected intravenously in healthy non-irradiated dogs. The injectednon-irradiated dogs will be observed for evidence of shock, femoral blood pressure alterations, temperature alterations, and mortality. If indicated, analysis of the lymph from the injected non-irradiated dogs will be undertaken as outlined above in phases one and two for the lymph of irradiated dogs.

Phase 5. The pathologic sequence of events in mice exposed to 1100 r (LD 100), 850 r. (LD 50) and 625 r. (LD 10) total Body X-irradiation.

The objective of this phase is to determine the time sequence of appearance of certain morphologic changes in the tissues of mice subjected to LD 100/30, LD 50/30 and LD 10/30 amounts of total body irradiation.

Project Title: Medical Defensive Aspects of Atomic Warfare

(c) Subtasks (cont')

MM 006 012.04 Biological Effects of Radiation. (cont')

Phase 5 (cont')

Healthy white mice will be exposed to 1100 r (LD 100), 1000 KV X-rays in groups of 200 for a total number of 900 to 1000 mice. Ten mice will be killed and autopsied at hourly intervals after irradiation. Microscopic sections of liver, spleen, sternal marrow, and intestines will be prepared and studied for morphologic changes. The rate of appearance of these changes and the extent of damage will be charted and an accurate pathologic pattern established. This will serve to further illustrate the complex mechanism of the lethal effect of ionizing radiation. The same procedure will be followed for the LD 50 and LD 10 groups of 1000 mice each.

Phase 6 The effect of total body X-irradiation on certain antigen and antibody systems in white mice.

The objective of this phase is to determine the relative ability of immunized and non-immunized irradiated and non-irradiated mice to withstand challenge doses of certain bacterial agents.

It is well known that irradiation has a profound effect on the cellular defense mechanism, but what part, if any, the antigen-antibody mechanisms play in the development of secondary infections in irradiated subjects is not understood. It is our purpose to endeavor to elucidate this interesting and important defense mechanism as it relates to total body irradiation.

White male mice will be used to determine the LD_{50}(7 days) of each of the following materials: tetanus toxin, typhoid-paratyphoid and pneumoccus bacterial suspensions (or streptococcus or staphylococcus toxin). The data will be determined for irradiated and non-irradiated mice.

Once the LD_{50} (7 days) of these bacterial agents is determined the mice will be immunized with one to three weekly subcutaneous injections of the corresponding antigens. After an interval sufficient for the development of antibodies (2 to 4 weeks) the mice will be irradiated with the $LD_{50}/30$ days of 2000 KV X-rays. Groups of mice will be challenged with homologous agents at various time intervals beginning as soon as practicable following irradiation and continuing for a period of six days. The animals will be observed for clinical behavior, mortality and pathologic changes.

Tetanus toxoid was chosen as an antigen because the cellular response is minimal and the condition is limited to neurotoxicosis. Typhoid-paratyphoid vaccine elicits a minimal granulocytic response and a measurable lymphocytic response.

The pneumococcus elicits a strong granulocytic response but no lymphocytic response. Each of these antigens is easily obtainable, easily standardized and is capable of producing a strong antibody response.

Project Title:- Medical Defensive Aspects of Atomic Warfare

(c) Subtasks (cont')

NM 006 012.04 Biological Effects of Radiation (cont')

Phase 9 Correlation of lethal effects of radiation and organ pathology with the presence of toxic products other than histamine.

The objective of this phase is to further elucidate the lethal mechanism of ionizing radiation by the correlation of certain lethal effects and organ pathology with the presence of toxic products other than histamine.

1. Tissue extracts from normal and irradiated animals will be prepared. Extraction methods will exclude the presence of histamine and choline. These extracts will be studied (a) by injection into mice having received X-ray doses producing various percentages of mortality ranging from 30 to 100 per cent, in order to observe their influence on mortality rate and radiation induced organ changes; (b) evaluation of the toxicity of these organ extracts by bio-assay methods using isolated intestine, heart, muscle and other organs as test objects.

2. Study of the effects of well-known drugs as atropine, histamine, adrenalin, etc., on isolated organs such as intestine, uterus, heart or muscle from animals having been previously exposed to X-ray doses producing various percentages of mortality and being removed from these animals at various time intervals after exposure.

3. These observations will be correlated with the histopathological findings obtained in Phase 8.

Phase 10. Physico-chemical methods of gamma ray dosimetry.

The objective of this phase is to study the effects of ionization radiation on various materials in order to find a substance which has properties suitable for dosimetry use.

This study has progressed in the direction of experiments on the coloration of alkali halide crystals by exposure to X-rays and gamma rays. Much of the pioneer work from which this phenomena has been described was done by Pohl and his co-workers in Germany. The sensitivity of KBr crystals to X-rays can be greatly increased by a process of "activation" involving "F" center creation in the crystal lattice and hydrogenation. The crystals then show promise of meeting many requirements of a suitable personnel gamma-ray dosimeter.

The dosimeter should be a rugged, reliable device which will immediately change color or some physical characteristic in proportion to the dose of gamma rays received. It should require no delicate reading instruments nor special processing. A dosimeter of this type is also needed in connection with the measurements of depth dose in large animal experiments.

Project Title: Medical Defensive Aspects of Atomic Warfare

(c) Subtasks (cont')

NM 006 012.04 Biological Effects of Radiation, (cont')

Phase 11. The measurement of adrenal function in acute body irradiation.

The objective of this phase is (1) to determine adrenal function in irradiated animals and (2) to ascertain the role of the adrenals in the pathogenesis of radiation illness.

Experimental Design:

1. Determination of the sensitivity of adrenalectomized animals to radiation by:
   a. Comparative dosage mortality curves
   b. Comparative biochemical and hematologic responses.
2. Effect of radiation on adrenal histology by:
   a. Phase microscopy
   b. Polarized light and autofluorescence
   c. Fat stains
3. Test adrenal reserve at various intervals after irradiation by the response to a test dose of ACTH using the Throne techniques:
   a. Direct eosinophil count
   b. Uric acid, creatinine, and allantoin excretion
   c Corticoid excretion
4. Daily corticosteroid excretion, particularly 17 ketosteroids for a measure of the "N" hormone and 11-oxysteroids for a measure of the "S" hormone.
5. Measurement of levels of adrenal cortical hormones in the adrenal vein.
6. Correlation of corticoid excretion with arterial K+ levels and K+ excretion
7. Excretion of 17 ketosteroids in patients undergoing X-ray therapy in relation to:
   a. Anatomic area irradiated
   b. Volume of tissue irradiated
   c. Sensitivity of the tumor

Project Title: Medical Defensive Aspects of Atomic Warfare

(c) Subtasks (cont')

NM 006 012.04 Biological Effects of Radiation (cont')

Phase 12. The hemorrhagic syndrome in acute radiation illness and the relation to circulating anticoagulants.

The objective of this phase is to elucidate the pathogenetic factors of the hemorrhagic syndrome of radiation illness. The hemorrhagic syndrome has been shown to be a prominent lethal feature of radiation illness in all mammals. Our studies will be concentrated upon the dog before being extended to other animals.

Dogs will be given doses of radiation, whole body, 2000 KV that are known to produce a severe hemorrhagic diathesis. Serial studies will be performed on the clotting time, platelets, and white blood cells. When a hemorrhagic diathesis develops a battery of tests will be performed on the blood and plasma of the dogs, direct and indirect assays for heparin, tests for anticoagulants, prothrombin conversion and concentration, and fibrinolysin. If an anticoagulant is not found it will be concluded that infection, thrombopenia, and localized ulcerations into the vascular bed are the prominent causes of hemorrhage and the phase will be discontinued.

Phase 13. The determination of low-level radioactivity in animal tissues.

The objective of this phase is to investigate methods for the determination of radioactivity in animal tissues.

The explosion of an atomic bomb may result in the wide contamination of areas with minute quantities of radioactive elements. Plants and animals living within such areas may be expected to absorb and retain these radioactive substances within their tissues. The quantitative determination of these low levels of activity are obviously of importance in the investigation of many biologic problems which arise from such situations.

It is planned to investigate quantitative methods for the determination of low levels of radioactivity in animal tissues, particularly alpha emitters, and use this technique for current investigations. The methods contemplated are:

1. The method of Dr. Herman Yagoda, "Tracks of densely ionizing particles in nuclear emulsions," Nucleonics 2(5): 2-5, (1948).
2. A modified string electrometer for measurement of densely ionizing particles.
3. Concentration and separation of specific radioactive substances as fission products for measurement by appropiate means.

Project Title: Medical Defensive Aspects of Atomic Warfare

(c) Subtasks (cont')

NM 006 012.04 Biological Effects of Radiation (cont')

Phase 14. Histopathology of oral tissues and organs subjected to ionizing radiation.

The prime objectives of this phase will be to attempt to discover oral changes which may be of prognostic value in a survey of atomic war casualties, to correlate tissue changes with physiologic function (as in salivary gland function), and to investigate the value of certain prophylactic or therapeutic measures as applied to oral tissues.

This study pertains to morphologic analysis of tissue sections taken from jaws, salivary glands, tongue, gingiva and other oral areas of irradiated animals. Correlations will be made between dosage, degree of change, time required for changes to occur, target distance and similar factors which may be of importance in the field d active atomic warfare. The methods which will be applied will include gross oral study of irradiated animals, some of which will be fortified by pharmaceutical and antibiotic compounds; histologic study of oral tissues; X-ray studies of hard tissues as well as histologic study of specially prepared ground sections and celloidin sections; correlations with biochemical assays of saliva; correlations with bacteriologic study of oral micro-organisms; studies of tooth development factors in young animals.

Phase 15. Influences of ionizing radiation on oral hard structures (development of dental caries and jaw necrosis).

The objectives of this phase are to elucidate more clearly the mechanism of destructive effects of ionizing radiation on the hard structures of the oral cavity as observed in Japanese atomic casualties and patients being treated for oral malignancies by X-rays; to ascertain the significance of improper mouth hygiene and dental caries for evaluation of calculated risks in atomic warfare; and to develop proper preventive and curative measures in the field or oral pathology in atomic warfare.

For these studies a specific strain of dental caries susceptible white rats which have been bred, reared, and studied by the Dental Division, NMRI, for the past four years, will be used. Standards of dental caries susceptibility on specific dietaries under vermin-free, temperature controlled conditions have been set up, permitting accurate evaluation of radiation effects using dental caries as a measure. Statistical formulae have been developed and applied for analysis of the factors operating such as litter, sex, diet, weight gain, food and water intake. The development of this colony of rodents and the control of variables which ordinarily operate, but may not be considered in other studies, has presented a method useful in evaluating oral effects of ionizing radiations. The rodents will be exposed for varying periods to ionizing radiations and the oral effects studied

[illegible]

[illegible] study of the [illegible]
and radiogermanium

The objectives of [illegible] is to study the kinetics in the organs of experimental animals of the [illegible] and injected of certain compounds of germanium and the determination [illegible] to study its excretion mode and place of deposition, and the pathological changes indicated thereby.

Experimental design:

A. An extensive literature search has been completed covering the physiological activity of Germanium. Some work has been done during the past 20 years on the effects of Ge on blood formation. In large part the results are contradictory. No significant study of the pharmacology of Ge has been reported. Since Germanium is a product of fission it is felt that a study of the physiological characteristics of this element is needed.

B. Laboratory approach:

1. Development of a suitable soluble compound for the artificial ingestion of Ge, both parenterally and orally.

2. Development of a chemical method for the determination of Ge in tissues and excretion.

3. Determination of the places, determination rate and routes of excretion, histochemical basis for these findings.

4. Determination of the toxic limits for several species of animals for several soluble Ge compounds, and the pathological changes induced by the toxic action.

5. A study of the physiological effects of the introduction of (Ge^{77}) into animals ($GeCl_4$, 11.4 day half life, 3 curies, 0.6 mev gamma).

6. It is planned to use conventional chromatographic, histochemical methods in these studies and to supplement them with radiochemical techniques.

[illegible]

2. [illegible] the cause of [illegible]

The objectives [illegible] of [illegible]

1. [illegible] lethality of [illegible] body X-ray.
2. The clinical and histologic [illegible] of radiation [illegible]
3. [illegible]

[illegible] et al. has shown that sulfhydryl enzymes are inhibited by ionizing radiation in vitro and in vivo [illegible] This inhibition can be partially [illegible] by the addition of SH containing agents to the in vitro system. This suggests that SH agents may be of [illegible] in the therapy of radiation illness.

Glutathione and cysteine have been shown to be [illegible] in lowering the toxicity of whole body [illegible] Subsequent [illegible] are being directed toward an understanding of the nature of this protection. The use of glutathione will be [illegible] because of the [illegible] Studies on [illegible] and histologic response of [illegible] and not [illegible] are underway [illegible] of Intat [illegible]

[illegible] Correlation [illegible] clinical [illegible] patients [illegible] therapy.

[illegible] objectives [illegible] feasible for the [illegible] ionizing radiation.

Attempts will be made to correlate [illegible] radiation illness with certain other phenomena such as [illegible] sensitivity, basal metabolism [illegible] body weight. The [illegible] and [illegible] (radiation sickness) will be carefully observed in patients [illegible] therapy. Threshold dose levels [illegible] for the production of [illegible] and changes [illegible] of [illegible] site of the [illegible] section of the body and [illegible] of the [illegible] of radiation sickness in patients [illegible] recording of all pertinent data will [illegible] employed [illegible] found useful in [illegible]

Furthermore, studies on changes in [illegible] [illegible] excretion will be included [illegible]

COPIED: 10/26/94
RECORD GROUP: #330
ENTRY: #346A
FILE: (in box #)

COPIED: 10/26/94
RECORD GROUP: #330
ENTRY: #346A
FILE: (in box #)