COPY

TO: Carroll L. Tyler, Manager, SFO

OCT 16 1953

FROM: Seth R. Woodruff, Jr., Field Manager, Las Vegas Field Office

SUBJECT: SHEEP LOSSES AROUND CEDAR CITY

SYMBOL: NEA

Reference is made to memorandum from Paul B. Pearson to John C. Bugher dated October 8, 1953, subject as above.

On October 13 and 14, 1953, Lt. Col. John H. Rust, University of Tennessee Agricultural Research Program, Oak Ridge, Tennessee, and Joe Sanders of this office made a trip to Cedar City to check on condition described in the referenced memorandum and to secure tissues, bones, etc., for further examination at Oak Ridge Laboratories.

We discussed continuing sheep losses with and , local wool growers, and Steven Brower, County Extension Agent. Drs. Holmes and Wolff, both of U. S. Public Health Service, are expected in Cedar City the last week of October. Many of the sheep are still on the mountain (October 14, 1953).

A new development in the sheep problem is that many of the yearling ewes have not experienced normal growth nor developed normal tooth structure. claims to have upward of 300 such animals. Mr. claims to have a lot of them, but did not know how many.

The lambs born in March and April of 1953 are larger than the yearling ewes born in the Spring of 1952. Four of the undersized ewes we slaughtered for tissues together with ewes and lambs grazed locally and those that winter ranged in Nevada.

The Cedar City people were told in late July that, on the basis of present planning, the Nevada Proving Grounds will not be activated for tests during the next twelve months and if there is any change in that planning they will be notified.

According to , and probably are going south into Arizona with their sheep this winter. He and have no other place to go and will have to go back to Nevada.

COPY

Both and ..agree that summer losses of sheep cannot be determined with any degree of accuracy until flocks are brought down from the summer mountain range. .. advises that most of the local wool growers are financed through local banks who, after the lambs are sold, will have accurate figures on losses and remaining sheep in herds. These figures are also available for previous years.

For your information

Jesse Summers

COPY

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We discussed continuing sheep losses with _____ and _____, local wool growers, and Steven Brower, County Extension Agent. Drs. Holmes and Wolff, both of U. S. Public Health Service, are expected in Cedar City the last week of October. Many of the sheep are still on the mountain (October 13, 1953).

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According to _____, _____, and probably _____ are going south into Arizona with their sheep this winter. He and _____ have no other place to go and will have to go back to Nevada.

Both _____ and _____ agree that summer losses of sheep cannot be determined with any degree of accuracy until flocks are brought down from the summer mountain range. _____ advises that most of the local wool growers are financed through local banks who, after the lambs are sold, will have accurate figures on losses and remaining sheep in herds. These figures are also available for previous years.

Damage to the skin of animals from radioactive fall-out has been recognized in horses during the last series of tests at the Nevada Proving Grounds and in cattle during the Spring of 1952 tests. In both cases the animals were located within a few miles from the site of detonation and in areas of relatively heavy fall-out. About the first of June, there was reported incidents of sheep, originally grazing in Nevada, showing lesions and also about 1400 ewes and 2900 lambs had died within the preceding few months. The question was raised as to the possibility of radiation damage causing or contributing to the lesions or deaths.

The same lesions were noted on sheep in areas of little or no fall-out with approximately the same incidence as in areas of relatively heavy fall-out. The general amounts of fall-out in the areas under question have been determined. These quantities of radiation dosage are not known to be sufficient to produce the lesions noted.

Evidence has been gleaned from microscopic examinations and comparisons of tissues both from the sheep in fall-out areas and some sheep on which skin beta burns were produced experimentally.

All of these data present a preponderance of evidence to support the conclusion that the lesions were not produced by radioactive fall-out. However, due to some anomalies in the evidence, it is recommended that studies be continued in order to determine the causative agent and to explain its isolated occurrence.

In considering radiation damage to the internal organs, the most critical is the thyroid, due to the uptake of radioactive iodine from the fall-out material. The amount of highest radiation dosage to the thyroid has been calculated to be far below the quantity necessary to produce detectable injury.

October 16, 1953

John H. Rust
University of Tennessee
Agricultural Research Program
Box 142
Oak Ridge, Tennessee

Dear Dr. Rust:

This is in regard to the letter of October 14, 1953, from Stephen L. Brower, County Agricultural Agent, Cedar City, Utah, of which you should have received a copy.

We are most interested in receiving tissue samples and one-half of the bone samples which you will note is mentioned in the letter. Would you please send these to Dr. Robert C. Bay, DVM, Radiobiology Laboratory, College of Medicine, University of Utah.

The information we have received concerning this investigation is greatly appreciated.

Sincerely yours,

M. A. Holmes
Veterinarian
States Services

MAH/wh

COOPERATIVE EXTENSION WORK

IN

AGRICULTURE AND HOME ECONOMICS

STATE OF UTAH
CEDAR CITY

UTAH STATE AGRICULTURAL COLLEGE
U. S. DEPARTMENT OF AGRICULTURE
AND IRON COUNTY COOPERATING

October 14, 1953

EXTENSION SERVICE
County Agent and
Home Demonstration Agent
Work

Dr. M. A. Holmes
Public Health Veterinarian
State Department of Health
Salt Lake City, Utah

Dear Dr. Holmes:

Wednesday morning Dr. John H. Rust and Joe Sanders of the A&C, with the assistance of Dr. Ray Burgess, obtained tissue and bone samples from eight head of spring lambs that had been raised in Cedar Valley and are assumed to have not been affected by what ever has affected the sheep that ran on the west desert last year. Also four head of yearlings and one old ewe were brought in by the sheepmen out of the affected herds and slaughtered.

Dr. Rust took the feet of all of the sheep as well as tissue samples from the thyroid, a lymph node from the internal mammary region, and a sample from the spleen. He said that he would split with you all of the tissue samples and you were to let him know if you would like half of the bone samples. He said it would five or six days before he would start working on the bones. If you should contact him before then if you wanted samples of the bone he would send you those also.

It is planned later on in the season to obtain a fetus for study from affected herds.

In regard to your proposed trip down here the last week of October, would you like to help on the stock or while you are here or do you intend just to check the herds?

Sincerely

Stephen L. Hansen

Stephen L. Hansen
County Agri. Agent

SLH:ef

cc: John H. Rust
University of Tennessee
Agricultural Research Farm
Box 817
Knoxville, Tennessee

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FEDERAL SECURITY AGENCY

ROUTE SLIP

(Fold here)

Date 11-4-53

To:	Constit. Organ.	Bldg.	Room
1. Dr. Holmes			
2.			
3.			
4.			
5.			
6.			

☐ Approval	☐ Note and return	☐ See me
☐ Comment	☐ Note and file	☐ As requested
☐ Necessary action	☐ Prepare reply	☑ For your information
☐ Investigate	☐ Signature	☐ Per conversation

REMARKS:

222

(Fold here for return)

From / To: Arthur W. Wolff

Bldg. _____ Phone _____

Room _____

16—39684-3 GPO

TED

OCTOBER 26 - 29, 1953

e meeting were Allair, Sanders,
Dunning from the AEC, Melvin
and Holmes and myself from the
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Also, quadrants were delineated
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of the same animal but for these
strontium applicator was used.
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Dosages in the order of 10,000 reps
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the pathology report on the Cory

e performed with the second sheep;
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ere used for this animal. Follow-
as shorn to facilitate observation
of effects. There was at the time of observation no pathology apparent in this animal. However, only 10 days had elapsed since the time of exposure.

In both animals serial sections for histopathology are planned. A start in this direction has already been made with animal No. 1 - 30 day histopathology sections having been made.

Dr. Bushbaugh is the experimental pathologist in charge of this experimental work. I was quite impressed by his competence and objectivity in conducting this experiment. Dr. Trum indicated that a similar experiment is being initiated at Oak Ridge.

Actually the data presented at this meeting did not throw much light on the Utah sheep situation except perhaps to cast a little more doubt as to the implication of radiation in the production of skin lesions on the Utah sheep in question.

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RESTRICTED

RESTRICTED

REPORT OF TRIP TO LOS ALAMOS, OCTOBER 26 - 29, 1953

The principal representatives at the meeting were Allair, Sanders, Lushbaugh, Trum, Shipman, Thompsett and Dunning from the AEC, Melvin from the U. S. Bureau of Animal Industry and Holmes and myself from the PES. The primary purpose of the meeting was to observe on sheep the early stages of beta burns experimentally produced at Los Alamos under the direction of Dr. Lushbaugh.

Two sheep were used in this study. Areas on each side and flank of one sheep were closely sheared and twelve small squares were delineated on one side of one animal. Also, quadrants were delineated on the ear and muzzle of this animal for the purpose of defining areas to be exposed. Dosages ranging from 2,500 reps to 25,000 reps were applied to the demuded sides and flanks. A 250 millicurie strontium 90 source was used to achieve these dosages. A similar range of dosages was reproduced on the ears and muzzles of the same animal but for these areas the commercial opthalmic type of strontium applicator was used. The sequence of pathology did not appear too dissimilar to the beta burns described for other species. The latent period seemed to be approximately 10 days or more and the threshhold for grossly apparent damage was approximately 2,500 reps. Dosages in the order of 10,000 reps were required in order to obtain necrotizing lesions. It will take another two or three months additional pathological study before these experimental data can be validly interpreted in the light of the Utah experience. At this early point there are certain similarities and dissimilarities in the gross pathology and histopathology of this experimental animal as compared with the pathology report on the ewe.

Similar exposure conditions were performed with the second sheep; only in this animal the dosage was applied with the full fleece intact. Dosages ranging up to 100,000 reps were used for this animal. Following the exposure period the fleece was shorn to facilitate observation of effects. There was at the time of observation no pathology apparent in this animal. However, only 10 days had elapsed since the time of exposure.

In both animals serial sections for histopathology are planned. A start in this direction has already been made with animal No. 1 - 30 day histopathology sections having been made.

Dr. Lushbaugh is the experimental pathologist in charge of this experimental work. I was quite impressed by his competence and objectivity in conducting this experiment. Dr. Trum indicated that a similar experiment is being initiated at Oak Ridge.

Actually the data presented at this meeting did not throw much light on the Utah sheep situation except perhaps to cast a little more doubt as to the implication of radiation in the production of skin lesions on the Utah sheep in question.

Dr. Dunning indicated that it was imperative that he prepare a statement for Commissioner Zukert of the AEC pertaining to the Utah sheep situation. This statement, claimed Dr. Dunning, is required before Commissioner Zukert will open up the "purse strings" for future continental weapons tests. Accordingly, a statement was agreed upon by the group heretofore listed. Dr. Dunning emphasized that this statement is for internal use only within the AEC and it is not to be construed as a joint PHS-AEC statement. The statement is as follows:

"Damage to the skin of animals from radioactive fall-out has been recognized in horses during the last series of tests at the Nevada Proving Grounds and in cattle during the Spring of 1952 tests. In both cases the animals were located within a few miles from the site of detonation and in areas of relatively heavy fall-out. About the first of June, there were reported incidents of sheep, originally grazing in Nevada, showing lesions and also about 1400 ewes and 2900 lambs had died within the preceding few months. The question was raised as to the possibility of radiation damage causing or contributing to the lesions or deaths.

"The same lesions were noted on sheep in areas of little or no fall-out with approximately the same incidence as in areas of relatively heavy fall-out. The general amounts of fall-out in the areas under question have been determined. These quantities of radiation dosage are not known to be sufficient to produce the lesions noted.

"Evidence has been gleaned from microscopic examinations and comparisons of tissues both from the sheep in fall-out areas and some sheep on which skin beta burns were produced experimentally.

"All of these data present a preponderance of evidence to support the conclusion that the lesions were not produced by radioactive fall-out. However, due to some anomalies in the evidence, it is recommended that studies be continued in order to determine the causative agent and to explain its isolated occurrence.

"In considering radiation damage to the internal organs, the most critical is the thyroid, due to the uptake of radioactive iodine from the fall-out material. The amount of highest radiation dosage to the thyroid has been calculated to be far below the quantity necessary to produce detectable injury."

October 27, 1953

Los Alamos Conference on Livestock Losses

Damage to the skin of animals from radioactive fall-out has been recognized in horses during the last series of tests at the Nevada Proving Grounds and in cattle during the Spring of 1952 tests. In both cases the animals were located within a few miles from the site of detonation and in areas of relatively heavy fall-out. About the first of June,* there was reported incidents of sheep, originally grazing in Nevada, showing lesions and also about 1400 ewes and 2900 lambs had died within the preceding few months. The question was raised as to the possibility of radiation damage causing or contributing to the lesions or deaths.

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*1953

STANDARD FORM NO. 64

Office Memorandum • UNITED STATES GOVERNMENT

TO : Mr. M. A. Holmes DATE: 11/2/50

FROM : J. H. Malone

SUBJECT: Los Alamos, N. Mex. meeting.

In accordance with your request enclosed are reports on the subject.

226

450 Federal Building
Salt Lake City 1, Utah
October 29, 1953

Chief, Bureau of Animal Industry
Washington 25, D. C.

Dear Sir:

In accordance with Bureau Letter B-, dated October 19, 1953, I proceeded to Los Alamos, New Mexico and attended the conference held there at the Health Research Laboratory on October 27.

Enclosed is a copy of the report issued by this group, for presentation to Dr. Paul B. Pearson of the Division of Biology and Medicine, A. E. C. The report is confidential, and is for the Bureau's information only. Also enclosed is a copy of my original report to the Bureau on the condition under discussion. The following A. E. C. men were in attendance at this meeting:

Dr. Gordon Dunning, A. E. C., Washington;
Mr. W. W. Allaire, A. E. C., Albuquerque;
Mr. Jas. Saunders, A. E. C., Las Vegas;
Dr. Shipman (University of California, at
Dr. Lushbaugh) Los Alamos, Health Research Laboratory.

The following veterinarians were present:

Col. B. F. Trum, U. S. A., Oak Ridge, Tennessee;
Dr. A. H. Wolff, U. S. Public Health Service, Cincinnati, Ohio;
Dr. H. A. Holmes, U. S. Public Health Service, Salt Lake City, Utah;
Dr. R. E. Thompsett, practitioner, Los Alamos, New Mexico.

Regarding the enclosed report, the entire morning was spent in discussing the slides prepared by the California men and by Dr. Trum and the lesions shown on the two experimental sheep referred to in the third paragraph of the report. There was considerable disagreement, but all present agreed to the final report submitted.

Regarding the experimental sheep: They were exposed to direct beta radiation from a projector held about 2 feet from the animals. A series of burns were made on the sides at measured intervals and of different degrees

of intensity, which were described as from 2,500 to 50,000 reps. The sides of the sheep had been sheared before exposure and the burns of lesser degree had healed on this, the 32nd, day. The scabs that remain do not appear to me to be the same as those observed at Cedar City on May 24. These appear to be just burns. Those at Cedar City I never saw before. Also those at Cedar, in some instances, covered the entire back and part of the sides of the animals and it is not known how old they were. They were first seen by the owners when they began shearing about April 15. The explosive tests in Nevada were on March 24.

Two more sheep have now been exposed to the same series of burns, but thru the full fleece. After one week the wool has been clipped from one animal and a pink discoloration is now seen. The other sheep is unshorn and nothing can as yet be observed. This experiment as well as the first will be continued by these University of California men.

In further recommending that studies be continued, it was brought out at the meeting that some of the sheep concerned in the Cedar City district graze south of the Dixie National Forest, south and east of Cedar, in the summer. These sheep are off of the forest in October and graze and trail west to their winter range in Nevada, arriving in November, to remain for the winter. During the extreme droughts in 1934-5 it was reported that there was a considerable growth of the Colorado Rubber Plant on this summer range, and much overgrazing. Sheep losses were reported. It was the thought at the meeting that this movement of sheep should be observed this year. Also the pathologists present desire very much to obtain more skin tissue, if available, for further study.

Very truly yours,

P. H. Melvin
Veterinarian in Charge
Disease Control & Eradication

Encl.

OFFICIAL USE ONLY

AEC 604/3

November 4, 1953

COPY NO. _____

ATOMIC ENERGY COMMISSION

SHEEP LOSSES ADJACENT TO THE NEVADA PROVING GROUNDS

Note by the Secretary

1. The attached report by the Director of Biology and Medicine is circulated for the information of the Commission.

2. Because of the limited number of copies Appendix "A" and the photographs mentioned in paragraph 10 are attached only to copies 1-8, 11 and 45.

ROY B. SNAPP
Secretary

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ATOMIC ENERGY COMMISSION

SHEEP LOSSES ADJACENT TO THE NEVADA PROVING GROUNDS

Report by the Director of Biology and Medicine

1. During April and May of 1953 several sheepmen who wintered their sheep north of the Nevada Proving Grounds encountered unusually heavy losses after the sheep were moved to the vicinity of Cedar City, Utah. The magnitude of the losses ranged up to 30 per cent for the lambs and 20 per cent for the ewes or mature sheep. The total number of deaths occurring during the two-month period of April and May is not precisely known. However, reasonable estimates run as high as several thousand.

2. The sheep were examined by experts from the AEC, U. S. Public Health Service, Bureau of Animal Industry, Naval Radiological Defense Laboratory, and the Utah State Agricultural College. Radiological examinations were made of external activity, the activity in the fleece, various organs and bones. Pathological and hematological studies were made of the tissues and blood of affected animals. No positive evidence was found of an infectious organism that could account for the abnormal losses.

3. While the majority of those who made a study of the sheep losses are of the opinion that radiation and the activities incident to the spring test did not contribute to the abnormal losses of sheep, there was a lack of unanimity of opinion. While in the opinion of the Division of Biology and Medicine the evidence so far does not justify a present conclusion by us that the spring tests were factors in these losses, the lack of unanimity of scientific opinion, combined also with the lack of positive findings as to the etiology of the losses, necessitates additional

work before a final scientific conclusion can be reached. The pathology of external beta lesions in sheep is now being studied experimentally at the Los Alamos Scientific Laboratory and at the UT-AEC Project at Oak Ridge.

BACKGROUND

4. The area north of the Nevada Proving Grounds beginning in the vicinity of the Lincoln Mine extending north to the White River Valley and east to Pioche, Caliente, and the Utah line is used as a winter range for sheep. The sheep are run in herds ranging in number from about 1,100 to 2,000 head. Many of the herds of sheep grazed in this area are owned by sheepmen who reside in the vicinity of Cedar City, Utah. The general locations of the winter grazing areas of the various sheepmen residing at Cedar City are shown on the map Appendix "A". The map also shows the infinite gamma radiation in areas adjacent to the Nevada Proving Grounds. The sheep range over a considerable area with the herder moving his camp periodically. It is not possible to fix the precise location of the sheep at any given date.

5. The sheep are normally moved either by trail or by truck, from the Nevada winter range to the Cedar City area between April 1 and April 20 depending on feed conditions and the weather. The sheep are usually kept west of Cedar City during the shearing and the lambing periods, and during this period the general practice is to provide some supplemental feed in the form of roughage or concentrates. The sheep are shorn shortly after they arrive at the Cedar City area and prior to lambing. The major period for lambing is between April 15 and May 15.

6. Heavy losses of both lambs and ewes occurred in herds of sheep around the Cedar City area this year between April 25 and May 25. The operators who suffered heavy losses wintered their sheep north and east of the NPG. The lambs and ewes died shortly after lambing. On the basis of information furnished by several sheepmen the losses ranged from 13 to 28 per cent counting about an 80 per cent lamb crop. The sheepmen do not keep accurate records of sheep that die, hence, reliable information is not available on losses even in normal years. However, several of the sheepmen were interviewed by Mr. J. B. Sanders, of the Las Vegas Field Office and some information obtained on dates of moving from the Nevada winter range to the Cedar City area, shearing time, number of lambs and ewes that died and other pertinent information. The detailed information obtained form the sheepmen is recorded in Appendix "B". It is estimated that the total losses of sheep in the area may run to several thousand. Not all operators who wintered sheep in the Nevada area reported unusually heavy losses.

7. There was fall-out of radioactive material from the March 24 detonation in the area north of the NPG where many sheep were wintered. There was also fall-out around Cedar City from the May 19 detonation. The herds in which heavy losses occurred had been moved to the Cedar City area prior to May 19.

8. A large percentage of the sheep in the affected herds showed lesions on the face and back after shearing. The sheep were first examined by Dr. A. C. Johnson, a veterinarian of some 30 years practice in Cedar City. He reported that he had not previously seen any lesions or losses comparable to those he encounterd in the Cedar City area this year.

9. Subsequently, several experts in the field of radiation and the diseases of sheep inspected the affected herds around Cedar City. Tissues and organs were examined for radioactivity, pathological lesions and infectious organisms. Dr. F. H. Melvin, Bureau of Animal Industry, and J. I. Curtis, veterinarian for the State of Utah, examined some of the sheep the latter part of May. They were unable to make a diagnosis of the malady.

10. On June 5 and 6 the following USPHS veterinarians, M. A. Holmes, W. G. Hadlow, and A. H. Wolff; Major R. J. Veenstra, USNRDL; and Dr. R. E. Thompsett, veterinary consultant to the AEC at Los Alamos, investigated losses of sheep in the Cedar City area. On the basis of information obtained from the operators it appears that the majority of mature sheep in the affected herds manifested typical progressive stages of redness of the skin, desquamation, papule, small blisters, and pustules on the face, ears, and back. (See photographs.) The black sheep were affected similarly to the white ones, which tends to rule out photosensitization which is caused by several species of poisonous plants.

11. Bones of sheep that died in the vicinity of Cedar City during the spring were collected and the radioactivity measured. Practically all of the activity could be attributed to strontium 90 and yttrium 90. The activity was measured in both the shaft and the epiphysis. The bones of four young sheep were obtained from the farm. The sheep are wintered near Cedar City and have not at any time been in Nevada. The average strontium 90 content of the bones of four young sheep was 1.4×10^{-4} microcuries per gram of bone. The losses of sheep in the herd had not been abnormal this year. The strontium 90 content of the bones of four sheep of comparable age owned by and

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Because of the limited number of copies of photographs mentioned in paragraph 10 are attached only to copies 1-8, 11 and 45.

and wintered in Nevada was 1.9×10^{-4} microcuries per gram of bone. Both of these operators suffered heavy losses of sheep. It is apparent that the skeletal strontium 90 content of the sheep wintered in Nevada from herds where there was heavy mortality was not significantly different from that of sheep from herds that were not in Nevada and where there were no abnormal losses. Furthermore, the levels of activity in the bones of the lambs sampled were far below the levels than could conceivably impair the health of animals or cause observable effects.

12. Radiological examinations showed the presence of some radioactive material on the back. Readings up to 2 and 4 mr per hour above background were observed. It would appear that this was from the May 19 detonation as contamination from the March shot would have been removed to a large extent with the fleece at shearing.

13. The thyroid glands of several sheep examined showed varying levels of activity which on the basis of decay rate was chiefly Iodine 131. The estimation of the dose of radiation to the thyroid is based on both the activity found in the organ and known degrees of contamination due to fallout in the area where the sheep were grazing. The assumptions and figures used in the calculations were selected to give maximum levels rather than more probable average values. Sheep around Cedar City which had not been in Nevada could theoretically have received about 365 reps. The sheep wintered in Nevada could have received between 407 and 824 reps from Shot 2. If they were exposed to the fall-out from both shots 2 and 9, the maximum dose to the thyroid glands would have been 1190 reps.

Experimental work on the toxicity of Iodine 131 for sheep at Hanford has shown that a dose of 15,000 reps are required before the thyroid shows even histological changes and that doses many times higher are required before any gross observable effects occur.

14. The location of the sheep during the two detonations concerned was in the areas where the infinite gamma dosage would not exceed 5 roentgens.

15. The pattern of pathology and healing of the lesions in the sheep does not follow the pattern observed in cattle, horses, and goats. In these species beta lesions continue to be manifested as an ulcerative condition for many months and even two or three years, whereas in the affected sheep the lesions were healed within a period of two months. Relatively high levels of external beta radiation do not impair the general health of animals. There were no deaths or even observable impairment of the health or general well-being of horses owned by the , Cedar City, that developed beta lesions this year, or the Alamogordo cattle which received rather severe beta burns. Furthermore, the fleece of the sheep would afford some insulation or protection as the particulate matter tends to be held in the lanolin on the outer parts of the fleece rather than filtering through the fleece to the skin.

16. Dr. R. B. Thompsett of Los Alamos expressed the view that the lesions he saw on the affected sheep were typical beta lesions and that the AEC had contributed to the loss of the sheep. This represents a minority opinion as other authorities in the field of radiation and animal diseases were of the opinion that radiation was not a contributing cause to the death of the sheep. More recently, Dr. Thompsett has examined beta lesions

produced experimentally on sheep at the Los Alamos Laboratory. On the basis of the gross examination of the experimentally produced lesions he has reaffirmed his opinion that the lesions he saw on the sheep around Cedar City were produced from beta radiation. More precise pathological studies of the lesions will be made by experts on beta burns.

SHEEPMEN'S ATTITUDE

17. So far as the Division of Biology and Medicine is aware the sheepmen have not alleged that their losses were due to radiation or the spring tests at the NPG. The losses did coincide with the tests; and since veterinarians were unable to diagnose the malady, it naturally raised a question in the minds of the sheepmen as to whether or not there was a connection between the two events. The sheepmen have on several occasions expressed considerable satisfaction with the manner in which the Commission is handling the problem. They are, of course, anxious to know what caused the heavy loss. Atomic Energy Commission's interests in the test area, accordingly, make it highly desirable that, quite apart from our interest in scientific answers to problems such as this, we explore all avenues of information which might be fruitful and explain the facts as fully as possible to the sheepmen.

SUMMARY

18. The preponderance of evidence indicates that activities of the Commission at the NPG were not responsible for, nor did this contribute to the heavy losses of sheep that occurred in the Cedar City area this spring. Nevertheless, the fact that Dr. Thompsett who studied the sheep losses did not concur in this view makes it desirable to carry on further studies and investigations before a final conclusion is reached.

19. It has been agreed that when a final conclusion is reached on the etiology of the sheep losses, any public release of the information will be made jointly by the Commission and the Department of Health, Education and Welfare.

20. Investigations are now in progress at the Los Alamos Scientific Laboratory, and the UT-AEC project at Oak Ridge in which lesions will be produced on sheep from beta emitters. The pathology of the lesions will be compared with the specimens of skin showing typical lesions which were obtained from sheep in the Cedar City area.

21. It may be necessary to administer known amounts of Iodine-131 to sheep under conditions comparable to those under which the sheep were wintered in Nevada. This could be done through a research contract with the Utah State Agriculture College as they have a herd of experimental range sheep at Cedar City.

22. Research projects are now being developed with both the University of Nevada and the Utah State Agricultural College. These institutions will study general problems of sheep and cattle production in the vicinity of the NPG and the Cedar City area. A continuing effort will be made to determine the etiology of the abnormal sheep losses, and to make close observations of the livestock adjacent to the NPG during future tests.

APPENDIX "A"

Map of the Location of the Winter Range of Sheepmen and Infinite Dosage of Gamma Radiation in the Area.

APPENDIX "B"

Information Obtained by Interview with Sheepmen

APPENDIX "C"

List of Technical Persons who have been Concerned with Study of Losses of Sheep in Cedar City Area.

APPENDIX "A"

Because of the limited number of copies Appendix "A" mentioned in paragraph 10 are attached only to copies 1-8, 11 and 45.

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APPENDIX "B"

Information Obtained by Interview with Sheepmen

_____, Cedar City

Date of trailing from Nevada range - April 20
Trailing deaths - 6
Premature Lambing during trailing - small
Date started lambing - April 20
Ewes lost during lambing (2 to 3 yr. olds) - 300 plus
Number normal lambs lost - ?
Total number sheep - winter range - 3200
No. lambs lost at birth or immediately thereafter - 700
Shearing Count - no answer
Time lamb died after birth - few hours to several days
Period greatest loss occurred - last 30 days
Date of shearing - April 20
Skin lesion first noticed - April 20

Date trailing from Nevada range - 4/6 to 5/5
Trailing deaths - 35
Premature lambing on trail - 6 to 8
Date of lambing - May 9
Ewes lost during lambing (2 to 3 yr. olds) - 200
No. normal lambs lost - 600
Total number sheep - winter range - 1835
No. lambs lost at birth or immediatley thereafter - 500 to 600
Shearing count - 1400
Length of time lambs died after birth - 2 hrs. to several days
Period greatest loss occurred - May 15-25
Date of shearing - May 4 and 5

Bullock reported 10 ewes died during the day of June 11, 1953.

_____, Cedar City

Date of trailing - 4/1 - 4/8
Trailing deaths - 12-15
Premature lambing on trail - 0
Date of Lambing - May 2
Ewes lost during lambing (older ewes) - 200
No. normal lambs - ?
Total sheep (Winter Range) - 1375
No. lambs lost at birth or immediately thereafter - 400
Shearing Count - 1274
Length of time lambs died after birth - 1 hr. to I week.
Period greatest loss occurred - 5/5 - 5/20
Date of shearing - 5/7 - 5/8

_____, Cedar City

Date of trailing - 3/23
Trailing deaths - 10
Premature lambs on trail - 10-12
Date of Lambing - April 5-15
Ewes lost during lambing (2 to 6 yr. olds) - 12

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No. Normal lambs lost - ?
Total Sheep (Winter Range) - 2100
No. lambs lost at birth or immediately thereafter - 470
Shearing Count - 2017
Length of time lambs died after birth - 1 hr. to 5 days
Period greatest loss occurred - April 5-20
Date of Shearing - May 2

_____, Cedar City

Date of trailijg - 4/18 - 4/27
Trailing deaths - 12
Premature lambing on trail - 0
Date of lambing - May 2
Ewes lost during lambing - 300
No. normal lambs lost - 300
Total sheep - winter range - 1500
No. lambs lost at birth or immediately thereafter - 600
Shearing Count - 1375
After shearing count - 1175
Length of time lambs died after birth - 2 hrs. to 7 days
Period greatest loss occurred - May 1 - 20
Date of shearing - May 9-11

_____, Cedar City

and grazed their sheep in Nevada on range land located west and north of Pioche close to grazing area of Louis Ence. They began trailing sheep from winter range April 15. They report better than normal conditions with sheep this season. was on the range with the sheep and saw some of the N.P.G. Shots while there. It is the opinion of that most of the trouble the stockmen are having is attributable to poor management, improper care, etc. The gave their sheep a supplemental diet of protein and salt from 2 to 3 ounces. per day per head. Two of the post mortems performed June 14, 1953 were on sheep furnished from flock. The had heard of some sheep loss close to Alamo.

_____, Cedar City

Had herd of approximately 1600 sheep on range close to Modena, Utah, and Panaca, Nevada.
Moved sheep from Panaca area to Modena area on May 1, 1953. Had greater than normal loss, many dry, very little milk for lambs, but attributes trouble to drier than usual year. No beta burns on sheep - no loose wool. Mr. is of , Cedar City.

_____, Cedar City

ranged sheep in Ely Springs, Dry Lake Valley S.W. of Pioche and N.W. of Panaca. Lost 300 out of a herd of 1700 ewe yearlings - very poor lambing - ewes lost mother instinct, vitality. Sheep have sores on mouth and face, slipping wool, etc. reports 150 head of sheep died during two day cold snap.

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_____, Cedar City

Reports kind of rough year, but not too much trouble. Ranges sheep in White River Valley south of _____ range. Saw atomic clouds go over. Had few premature lambs but trouble no worse than experienced in previous dry years.

_____ - June 12, 1953

Had 1500 ewes - normal loss 50 ewes. This year 300 - marked 300 lambs expected to mark 1000 out of herd of 1500. Has possible 100 more lambs to mark. Unable to determine cause of sickness. They eat plenty but do not seem to recuperate. Hay and grain doesn't seem to help sheep.

UNCLASSIFIED

APPENDIX "C"

LIST OF TECHNICAL PERSONS WHO HAVE BEEN CONCERNED WITH STUDY OF LOSSES OF SHEEP IN CEDAR CITY AREA

Paul B. Pearson, Division of Biology and Medicine, AEC, Washington, D. C.
Gordon Dunning, Division of Biology and Medicine, AEC, Washington, D. C.
Kermit H. Larson, AEC-UCLA, Los Angeles, California
Bernard F. Trum (Lt. Col.) UT-AEC Agricultural Research Program, Oak Ridge, Tenn.
John H. Rust (Lt. Col.) UT-AEC Agricultural Research Program, Oak Ridge, Tenn.
C. L. Comar, UT-AEC Agricultural Research Program, Oak Ridge, Tenn.
H. H. Kornberg, General Electric, Hanford Works, Hanford, Washington

James G. Terrill, Jr., U.S. Public Health Service, Washington, D.C.
M. A. Holmes, U.S. Public Health Service, Salt Lake City, Utah
Arthur H. Wolff, Public Health Service, Cincinnati, Ohio
George Spendlove, Utah State Department of Health

W. T. Hoffman, Bureau of Animal Industry, Salt Lake City, Utah
F. H. Melvin, Bureau of Animal Industry, Salt Lake City, Utah

D. A. Broadbent, Utah State Agricultural College, Logan, Utah
James A. Bennett, Utah State Agricultural College, Logan, Utah
LeGrande Shupe, Utah State Agricultural College, Logan, Utah
D. A. Greenwood, Utah State Agricultural College, Logan, Utah
L. A. Stoddart, Utah State Agricultural College, Logan, Utah
S. L. Brower, County Agent, Cedar City, Utah

Darrell H. Matthews, Branch Agricultural College, Cedar City Utah
Max E. Robinson, Branch Agricultural College, Cedar City, Utah

William Hadlow, Rocky Mountain Laboratory, Hamilton, Montana

R. J. Veenstra (Maj.) U. S. Naval Radiological Defense Laboratory, San Francisco, Calif.

R. E. Thompsett, Consultant, Los Alamos, New Mexico

RESTRICTED

Medical Officer in Charge, CDC
Atlanta 5, Georgia

DATE: November 9, 1953

THROUGH: Alexander Langmuir, M. D.
Chief, Epidemiological Section.

ATTENTION: James H. Steele, Chief
Veterinary Public Health Services

SUBJECT: Report of Conference held at Los Alamos, New Mexico, on Utah sheep deaths and experimentally induced Beta-radiation burns on sheep.

FROM: Monroe A. Holmes
Veterinarian, Bureau States Services,
Utah State Department of Health ,
Salt Lake City, Utah.

As advised, by telephonic conversation with you and Dr. Cecil Reinstein of the Epidemiological Section, I left Salt Lake City, Thursday, October 22nd, and proceeded to Denver, Colorado, for conference with the Region #IX office, Dr. Henry Hassel, and Mr. Spencer, Administrative Officer.

I stopped on my way to Denver at Fort Collins, Colorado, and conferred with Dean Cross, Dr. Newsom, (Dean Emeritus) Colorado Veterinary College. We discussed the Utah sheep deaths in which the gross and microscopic pathology was thoroughly outlined. Dr. Newsom, who has done excellent work in sheep diseases in the past 40 years was not able to arrive at any definite conclusion as to what the pathology of these animals indicated. In the opinion of these men it seemed highly doubtful that we would have a new disease in these animals that had not manifested itself by spreading to other herds in which they may have come in contact, especially those herds that were contacted in Utah and had not been in the Nevada grazing area.

I proceeded to Los Alamos from Denver, after conferring with Martin Baum of the Colorado State Department of Health, discussing the present Utah State Department of Health Veterinary Program as well as the rabies cases which have occurred in Colorado.

On Monday, October 26th, I contacted Dr. R. E. Thompsett, Veterinary Consultant for the A. E. C., and went over his work on the experimentally radiated sheep at Los Alamos. Not wanting to formulate any early opinion prior to the meeting of the rest of the consultants, I did not see the sheep at this time.

On Tuesday, October 27th, the group of consultants met at the Health Research Center of the Los Alamos Project. We began the meeting by showing colored slides of the experimentally radiated sheep. The following A. E. C. men were in attendance at this meeting:

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Report of Conference held at Los Alamos, New Mexico - 2

Dr. Gordon Dunning, A. E. C., Washington;
Mr. W. W. Allaire, A. E. C., Albuquerque;
Mr. Jos. Saunders, A. E. C., Las Vegas;
Dr. Shipman (University of California, at
Dr. Lushbaugh) Los Alamos, Health Research Laboratory.
(Luncheon

Two sheep had been used in this experiment, both had been shorn with a fine clipper over the lateral aspects of the body--three rows of six squares each, approximately 4 inches in size, were marked off. Each square was exposed to 250 mr of strontium 90, being applied to the shaved areas in dosages from 25,000 reps. per minute through 20,000, 15,000, 10,000, 5,000, 2,500 reps. per minute. The stronger dosages were administered from the posterior square in decreasing dosages toward the anterior squares. In the next row the dosages were varied so that the stronger dose was anteriorly decreasing posteriorly. The third row was similar to first row. Both the muzzles and ears were divided into quadrants and exposed to similar dosages. Erythema was noticed on the body areas nearly immediately and subsided usually within 30 minutes.

In one week, pink areas began to occur with some scaling.
At 1½ weeks, definite reddening occurred, increasing from the original 5/8 inch exposed area to 1½ inches in diameter.
In 2 weeks the areas had no wool growth with definite erythema, scabbing, and some weeping.
In 3 weeks there was no appearance of deep ulceration, and lesions appeared to have begun to heal.
In 4 weeks the size of the lesions began to decrease and wool began to appear in the 2,500 rep. areas.
On the head, at 1 week, there was no apparent lesions.
At 1½ weeks there was no apparent lesions around the commissures of the lips. However, hair growth stopped and dermatitis was noticed.
In 2 weeks the dermatitis had increased on the lips but the ears showed no effect.
In 3 weeks the ears began to show erythema and dermatitis.
In 4 weeks there was some atrophy of the skin and scabbing. There, apparently, was no formation of pustules or vesicles seen.

After the slides were observed microscopic sections were seen which had been taken from one of the affected animals (Utah sheep- ewe) and compared with sections taken from horses which had similarly been affected on the range. In addition, biopsy specimens were shown. There was some difference of opinion among Veterinary Consultants, as well as by the pathologist of the Los Alamos Project, regarding the slides. The slides, taken from the affected Utah sheep, did not show the similar pathological changes as those taken from the horses. It was pointed out that the histology of the skin differed in these animal therefore, the pathological changes could possibly be dissimilar. Also, that the biopsy specimens from the experimental sheep was possibly different from that of the Utah sheep due to the difference in the time interval when the specimens were obtained. It was, therefore, conceded that further biopsy specimens should be obtained from the experimental sheep, at varying intervals, to determine if they possibly would correspond with those of the Utah sheep. Upon conclusion of the pathological slides the group adjourned to the animal

quarters and we all observed the experimental sheep.

In my personal opinion, I feel that the lesions seen on these animals were similar to those we observed on the Utah sheep. Although smaller in area, these had very similar gross appearances and were not like any other injury that may occur to sheep skin through traumatic wounds. The group again adjourned to the meeting room and a discussion was held on the appearance of the gross lesions.

Several of us felt that the induced radiation, through the shaved skin, was not as applicable as if it had been induced through the total wool growth which had occurred in the Utah sheep. We were then notified that one of the sheep had been experimentally radiated over the full-wool growth on the body, but this phase of the experiment had begun only a week to 10 days prior to our present examination and had not yet shown any changes.

The afternoon session was largely a discussion stage in which it was decided that it would be necessary, in order to arrive at some sort of conclusion, to continue the present experiments and investigations in public health, atomic energy, and Bureau of Animal Industry relations to this problem. Although we all did not agree with the conclusions, as a group, drawn up by Gordon Dunning of the Washington, D. C., Administrative Offices of the A. E. C., we were asked to sign this attesting to our attendance, which I did. The following is a copy of his conclusions, which were to be used as an internal report to the Commissioners of the A. E. C. Please note that this is not for distribution, and is for your own personal information, as it is considered an internal report of A. E. C.

After this conference adjourned I was asked by the pathologist of the Los Alamos Project, that while continuing my investigation of the Cedar City sheep, to determine if additional changes were still occurring in these animals. As I had intended to return via Cedar City, I agreed to notify him of additional changes and send pathological specimens which might be of interest.

Leaving Los Alamos I proceeded to Cedar City via Albuquerque, New Mexico, Flagstaff, Arizona, arriving in Cedar City, Thursday, October 29th.

I conferred with Steve Brower, County Agricultural Agent, Iron County, and he arranged for a meeting with the main sheepmen affected. Unfortunately, due to early frost and snow, the majority of the sheep had been moved out previous to my return to Cedar City. However, a few animals were left to be trucked out at a later date due to various reasons but principally because of weakened conditions. It was learned from the sheepmen, that, although the majority of deaths had ceased at the time of our June and July investigations, several of the sheepmen had lost both lambs and yearlings (1952 born sheep) while trailing them to the summer range. Some estimates were as high as 30 to 50 per 2,000 head of sheep. Accurate figures are not obtainable and would not be obtainable either on these losses or prior losses until Bank Examiners figures could be tabulated after sale of lambs and old ewes. This is in the process at the present time and should be available shortly.

We examined two herds that were still in the area belonging to Mr. , and Mr. , and . Of the lambs which had survived this year the majority of them were of a larger size than the yearlings (1952 born sheep). Additionally, along with this possible stunted and weakened condition, the yearlings lacked proper tooth growth. Although the teeth were of a normal appearance they had not erupted as would be expected of sheep this age. Arrangements were made, whereby, the black "counter sheep" were to be isolated from various herds and brought to Cedar City for examination to determine if there were any changes in pigmentation and skin or wool development. Also, the sheepmen were agreeable to have the white sheep run through selecting runways so that each could be observed to determine if there were any anatomical of wool growth or skin change.

In addition, upon my return to Cedar City, I plan to go to the areas where the dead sheep had been disposed of in order to try and obtain portions of pelts of these animals so that the pathologist in Los Alamos may be able to make additional sections.

Upon completion of my meeting in Cedar City I returned to Salt Lake City.

Respectfully submitted

Monroe A. Holmes
Veterinarian

MAH/wh
encl.

November 12, 1953

Dr. Clarence Lushbaugh,
Medical Health Research,
Atomic Energy Commission,
Los Alamos, New Mexico.

Dear Doctor Lushbaugh:-

Today, by parcel-post, I have sent you the tissue specimens as we mentioned in our telephone conversation. I have not attempted to identify these specimens due to the difficulty in obtaining those which we could consider significant as to the lesions which were observed earlier in the year. However, portions of ears will be seen, as well as some skin from the nose and commissures of the mouth and from the back. It was difficult to obtain anything from the areas of the nostrils and mouth as well as the back, because the major portions of deterioration of the skin were in these localities.

Of the twenty-some-odd sheep that were supposedly dumped in one location, we were able to find only four. There is no evidence that the other carcasses had been spread by wild animals and those we did find were exposed to all the elements, and consequently were pretty far gone. Perhaps four does look like twenty to the sheep owner, especially after his loss of several hundred head.

As far as we have been able to ascertain, the samples are from animals which had died during trailing from the home ranch to the summer range. In spite of the data which was given us, that the sheep men had suffered losses all through the summer, of those we talked to, which were the major losers, maintained additional losses had occurred only on the trail to their summer places.

Unusual data was that the sheep born in the Spring of 1952, considered to be yearlings, were of smaller stature and growth in all their physical formations, including teeth eruptions, than even the lambs which were born during the supposedly adverse conditions of 1953. We were unable to observe these animals for comparison as most of them had rapidly moved out from summer range because of the freezing weather, failing to give us advance information as to their movements.

Trusting that you will receive the sheep that we picked out, still indicating lesions, in good order and that you will send us any information you may find on the animal, I am

Sincerely,

MONROE A. HOLMES
Veterinarian
U. S. Public Health Service

MAH:uml

COOPERATIVE EXTENSION WORK
IN
AGRICULTURE AND HOME ECONOIMCS
STATE OF UTAH

CEDAR CITY
November 12, 1953

UTAH STATE AGRICULTURAL COLLEGE
U. S. DEPARTMENT OF AGRICULTURE
AND IRON COUNTY COOPERATING

EXTENSION SERVICE
County Agent and
Home Demonstration Agent
Work

Dr. R. H. Walker, Director
Experiment Station
U. S. A. C.
Logan, Utah

Dear Dr. Walker:

Last weekend Dr. M. A. Holmes, Public Health Service, was here in Cedar City and it was suggested that we make arrangements for a conference at Logan with the Experiment Station personnel to go over the details of the sheep losses last winter in Iron County, and possibly make some tentative suggestions on types of experimental program that might be set-up to investigate this problem.

Dr. Holmes indicated that he could come up Monday or Tuesday, and in as much as I will be there for Extension Conference I was wondering if we could have a luncheon meeting beginning possibly at 11:30 a.m. on Tuesday in one of the dining rooms at the Cafeteria.

The AEC has been notified of this suggestion also and may possibly send a man to Logan.

If for any reason it is impractical to hold this meeting at the above mentioned time and place please notify Dr. Holmes, Public Health Veterinarian, Disease Control Section, State Department of Health, Salt Lake City, Utah; and Mr. Joe B. Sanders, Acting Field Manager, Atomic Energy Commission, P. O. Box 2088, Las Vegas, Nevada.

I will check with you when I get to Logan Tuesday morning.

Sincerely

Stephen L. Brower
County Agri. Agent

SLB:sf

cc: Dr. M. A. Holmes
Joe B. Sanders
Russell Keetch

250

Meeting held in Extension Office at UAC Tues. 11:00 A.M. 11-17-53

November 23, 1953

C. C. Lushbaugh, M. D.
University of California
Los Alamos Scientific Laboratory
P. O. Box 1663
Los Alamos, New Mexico

Dear Doctor Lushbaugh: Rel: H-4

I was glad to know that the sheep and the somewhat old and worn specimens I sent were of help to you. I was only too glad to be of some small assistance.

I note that you are working diligently to wind up the laboratory work. I will certainly appreciate receiving a copy of your report when it is completed.

In the meantime, if I can be of any further help please feel free to call on me.

Sincerely yours,

M. A. Holmes
Veterinarian

MAH/wh

UNIVERSITY OF CALIFORNIA
LOS ALAMOS SCIENTIFIC LABORATORY
(CONTRACT W-7405-ENG-36)
P. O. BOX 1663
LOS ALAMOS, NEW MEXICO

IN REPLY
REFER TO: H-4

November 18, 1953

Dr. Monroe A. Holmes
U. S. Public Health Service
Utah State Department of Health
Salt Lake City, Utah

Dear Doctor Holmes:

We received the sheep (one) from Cedar City and the two bottles containing various bits of the outsides of some. We are now trying to deodorize, rehydrate, fix and generally refurbish the latter. The former, we have already biopsied. We found four large relatively linear but jagged wide scars still retaining scabs under the wool. None were on the back; two were on each side. The ewe, now named Cedar City Sue, survived the operation but is quite puzzled by the peculiar and obviously amateur shearing job she experienced.

We will certainly let you know of our findings as soon as we can. We are hurrying in order to get a report into Dr. Pearson's hands as soon as possible. It was exceedingly helpful of you to hunt this sheep for us and to obtain the bits from its long dead sisters. We appreciate this very much.

Sincerely yours,

C. C. Lushbaugh, M.D.

CCL:shf

a 3rd degree burn won't kill in spots.
1st degree burns may kill if extensive enough

COMPARATIVE STUDY OF EXPERIMENTALLY PRODUCED BETA LESIONS AND SKIN LESIONS IN UTAH RANGE SHEEP

by

C. E. Lushbaugh, J. F. Spalding and D. B. Hale

November 30, 1953

LOS ALAMOS SCIENTIFIC LABORATORY
LOS ALAMOS, NEW MEXICO

INTRODUCTION

While this report may be considered preliminary, it is actually a condensed and summarized version of experimental and clinical findings. It is "preliminary" only in that a second and final report is contemplated which will include all the experimental details and historical embellishments commonly employed in a finished report. This report is written in this unfinished form in order that any action that must be taken at this time in regards to the injury of the skin of Nevada sheep may be based in part upon these observations, if this is desired.

The experimental portion of this study was undertaken at the suggestion of Drs. Thomas L. Shipman and Wright H. Langham with the approval of Drs. John Bugher and Paul Pearson, all of whom felt that an appraisal from the point of view of possible radiological causation of the lesions found in the field would depend upon experimental determination of the amount of beta irradiation found necessary to produce similar lesions under controlled conditions.

EXPERIMENTS

Three experiments were done. For this purpose three sheep of common (NO) range quality were obtained through the kind services of Dr. Robert Thompsett. The beta irradiation was obtained from a strontium 90-yttrium 90 source, 15 mm in diameter, manufactured by the Oak Ridge National Laboratory. This source had been in use in this laboratory for at least two years and was found to deliver at its surface 5,400 rep/min. Previous experiments in rabbits had demonstrated the ability of this source to produce dermal ulcerations of reproducible characteristics.

The first experiment was done in order to determine the minimal amount of beta irradiation that was necessary to produce ulcerative lesions of the skin of sheep. Two sheep were used. One entire side of each sheep was shaved so that eighteen individual areas, 3 inches square, were obtained (Plates 1, 2, 3, and 4). There were three rows of six such areas. Six different exposures were used in each row so that each of the six areas received 2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 thousand rep beta, respectively. The next row received these exposures in the reverse order and the third row in the same order. The strontium disc was placed as close to the skin as possible so that the area directly irradiated was about 15 mm in diameter. The muzzle and the ears of each sheep were also shaved. Using a strontium ophthalmologic applicator made by Tracerlab and found to deliver 33 rep/sec, exposures of similar strength were made to the skin about the angles of the mouth and near the outside edges of the ears. The three lower doses were applied to the right ear and the right side of the face and the three higher doses were applied to the left ear and left side of the face (Plates 5 and 6).

The results of the first experiment can be summarized as follows: Ulceration was first seen in the areas of exposure to 25,000 rep in 8 days. It was seen in 13 days in the 2.5 thousand rep area in one of the two sheep (Plate 2). One failed to develop a lesion at 2,500 rep (Plate 1). The ulceration was quite superficial? in the lesion caused by 2,500 rep but obviously extended throughout the thickness of the epidermis in the case of the lesion caused by 25,000 rep. All of the areas were typical of ulcerative radiodermatitis or "radiation burn." Growth of wool was stopped in all areas of exposure except as stated below. The area of epilation and cessation of wool growth was larger than the area actually irradiated, and varied with the doses up to about twice the size of the area of ulceration. At three weeks post-irradiation (Plates

1 and 2), these areas had reached their maximum size and measured as follows: 2,500 rep, 15 x 15 mm; 5,000 rep, 20 x 20 mm; 10,000 rep, 25 x 19 mm; 15,000 rep, 27 x 22 mm; 20,000 rep, 28 x 25 mm; and 25,000 rep, 28 x 25 mm. Healing was complete by eight to nine weeks but wool growth had not returned by this time (Plates 3 and 4). The sheep, "D", that failed to develop lesions with the lowest dose also failed to show appreciable cessation of wool growth in the areas of the lowest dose. The lesions on the ears and muzzles of both sheep were identical in appearance and development with those on the sides except that there was a lag in the appearance of the lesions on the ears. These never became quite as ulcerative as those about the muzzles or on the sides of the sheep.

In the second experiment, a third sheep was used. No shaving was done, and the following exposures were made: 5,000 rep to the right ear and right angle of the mouth; 10,000 rep to the left ear and the left angle of the mouth. The larger Oak Ridge applicator that delivered 5,400 rep Beta/minute was used. Although daily observations were made, no evidence of damage in these areas was ever observed.

In the third and final experiment of this series, the first two sheep were used again. On the previously unexposed and unshaven side of each, four points, as far apart as possible, were marked on the surface of the wool. The larger applicator was then placed lightly upon the surface of the wool at each of these points for sufficient time so that the points beginning at the shoulder and extending to the rump and thigh received 5,400, 16,200, 48,600, and 145,800 rep, respectively. Immediately after irradiation the wool covering the four areas in sheep "D" was removed in order that the development of any lesions could be observed.

The results of this experiment were as follows: In sheep "H" it became

possible in 10 days to pluck the wool without force, from all the irradiated areas except the one exposed to the lowest dose. The staple length of this wool was 33 mm. Its ends (Plate 13) differed from those of wool fibers plucked (with force) from normal areas (Plate 12) in that the bulbous portion had been lost. An ulcer developed only under the wool exposed to 145,000 rep in sheep "H". Sheep "D" had proved to be more resistant than "H" by not developing a lesion in the first experiment after 2,500 rep. In this experiment, it was likewise more resistant than "H", since it did not develop an ulcerating lesion even at the highest dose area, and required about one week more before the wool could be plucked from the exposed spots with ease. The area exposed to the least amount of beta radiation in "D" could not be identified by plucking out the wool. In both sheep the areas of epilation were larger than the surface of the radioactive plaque. Maximum sizes were:

	Thousands of rep Beta			
Dose	5.4 rep	16.2 rep	48.6 rep	145.8 rep
Sheep "H"	0 mm	35 x 38 mm	50 x 50 mm	43 x 45 mm

These epilated areas are to be seen in Plates 1 and 2.

Dr. Tom White was able to make some calculations for probable skin surface doses when the staple length of the wool was 33 mm and had a density of 46.2 mgm/ccm. The results of these calculations (appendix) are of great aid in explaining some of the phenomena observed in these experiments. It was found that about three per cent of the dose delivered to the surface of the wool reached the surface of the skin directly under the plaque. Based on the figures, epilation in the sheep is found to require about 400 - 500 rep to the skin surface, a figure in good agreement with clinical experience in man. Ulceration occurred in sheep "H" after a calculated skin dose of about 4,375 rep (3 per cent of 145,600 rep) which agrees relatively well with the observation in the first

experiment that the threshold dose for ulceration is between 2.5 and 5.0 thousand rep. none from 2 500 which is probably more comparable

Biopsy specimens were obtained from 5,000; 15,000 and 25,000 rep lesions six weeks old and from a 25,000 rep lesion nine weeks old (all of which appeared to be healed). Histological preparations were made from these specimens and studied.

The lesions were found to be quite similar pathologically to those previously studied in rats, rabbits and man after exposure of the skin to beta radiation:

1. The scab or eschar. This was typically composed of serum and some cellular debris at the lowest dose and of coagulated and still recognizable elements of the upper dermis such as wool fiber and follicular shafts and glands at the higher doses. Leukocytes apparently made up a good part of the scab and played a proteolytic role in separating the dead cells of the eschar from the remaining viable ones. Scab retention in the sheep was probably as prolonged as it was (eight to nine weeks or more) because of the numerous attached wool fibers.

2. Reactive Epidermal Hyperplasia and Reepithelialization. The full thickness of the epithelium was not destroyed by 5,000 rep of beta radiation. In attempting to replace the cells damaged by radiation, a remarkable hyperplasia occurred and left a hypertrophic epidermis marked by follicles so thickened by this process that the foci resembled early squamous carcinomatous fingers.

Fifteen thousand rep caused a loss of the superficial epidermis in the outer one-third to one-half of the wool fiber follicles. Atrophy of the sebaceous glands was marked. Regeneration occurred early from the wool fiber follicle remnants. The new epidermis was quite hyperplastic and thickened. The margin

of the lesions had hyperplastic and hypertrophic epidermal "downgrowths."

Twenty-five thousand rep injured the full thickness of the dermis and the whole follicle was lost so that healing occurred by the ingrowth of sheets of epithelium from the surrounding, relatively uninjured, remaining cells.

In all cases the regenerating epithelium showed bizarre forms ranging from atrophy to giant cell formation.

3. Vascular and Other Connective Tissue Changes. Blood vessels were found to be increasingly damaged as the dose was increased, but hyalinization, intimal fibrosis, endothelial swelling, and thrombosis were found in all three lesions.

Fibroplasia occurred best deep in the dermis and was poor, if existant at all, in the outer layers of the skin where a chronic cellular exudate was found to be present.

Clinical Studies

a). Ewe 6 and 7. Specimens of these sheep (or this sheep?) were obtained from W. S. Hadlow, D.V.M. The skin lesion was remarkably similar, histologically, to severe beta ray burns as demonstrated experimentally.

The lesion was similar in respect to the eschar (which is histologically identical) and the manner in which the outer half of the wool fiber follicles have been lost.

These lesions, however, are dissimilar in that: epithelial hyperplasia is not seen; vascular changes are not found, and there is no evidence of post-irradiation atrophy of the follicles and sebaceous glands.

The injury seems to have been one in which the damage either killed tissue or did not injure it at all.

b). Cedar City Ewe. This sheep was received from Nevada on November 14,

1953. The lesions (Plates 7, 8, 9, 10, 11) were found on both sides of the animal and were roughly linear and jagged in shape. There were four lesions on the left side and three on the right side. The lesions appeared to point in opposite directions. The defect in the wool had obviously allowed dirt to penetrate to the skin in the surrounding normal wool so that large areas were discolored brown. Most of the lesions were scars devoid of wool. In places the scars retained hard (horn-like) scabs which could be pulled off with difficulty, leaving bleeding areas.

Wool plucked from these scars showed a loss of the bulb similar to that of the experimentally produced skin lesion.

Thus, it would appear from these gross observations that this and similar lesions seen in the field by Dr. Robert Thompsett and others, conform well enough to a presumptive diagnosis of a radiation-produced lesion.

On November 16, 1953, about 50 per cent of the large left flank lesion (Plate 11 L) was removed surgically for histological study. This study may be summarized as follows:

This lesion is now a scar covered by epidermis. All the skin appendages are absent in the central area under the scab showing that the injury was to the full thickness of the skin. The new collagen of the scar is orderly and contains an increased amount of normal capillaries, indicating that the scar is relatively young. There is some fibroplasia immediately under the epidermis. At the edges of the lesion the wool fiber follicles are missing in foci while others appear normal. Isolated sebaceous glands of normal appearance are found without their accompanying wool fiber follicles. The small blood vessels and especially arterioles fail to show changes typical of post-irradiation degeneration.

c). An attempt was made to survey as many histological preparations of

sheep skin disorders as possible in order to determine whether radiological changes such as these described could be produced by non-radiological means.

Examples of the following diseases were studied:

Contagious ecthyma
Filarial dermatosis
Actinobacillosis
Papillomatosis
Infectious postular dermatitis
Ulcerative stomatitis (bacterial)
Viral granulomatous dermatitis
Sore muzzle disease (bluetongue)

These specimens were obtained through the kindnesses of Drs. Chester Gleiser and T.C. Jones of the Armed Forces Institute of Pathology, Drs. Bertram Trum and John Rust of Oak Ridge, and Dr. Charles L. Davis, Regional Pathologist, Veterinarian in Charge, Denver.

This study substantiated the opinion that wool fiber follicle loss, focal loss of glands and/or follicles, superficial or deep dermal injury all similar to the changes seen in the sheep specimens obtained in the field could be produced as the result of skin injury caused by agents other than ionizing radiation.

d). At about the time this investigation was beginning, several rabbits were used to determine for another group at Los Alamos whether gases in liquid form would produce serious skin injury. Liquid nitrogen was one of the gases poured on to the skin. The resulting lesions are grossly and histologically similar to those of the sheep. This observation is mentioned in order to show that physical trauma can produce such lesions and not because it is felt that the lesions in the sheep were produced by freezing.

CONCLUSIONS

1. It would appear from these observations and experiments that a skin lesion of a sheep in full wool, involving the full thickness of the skin,

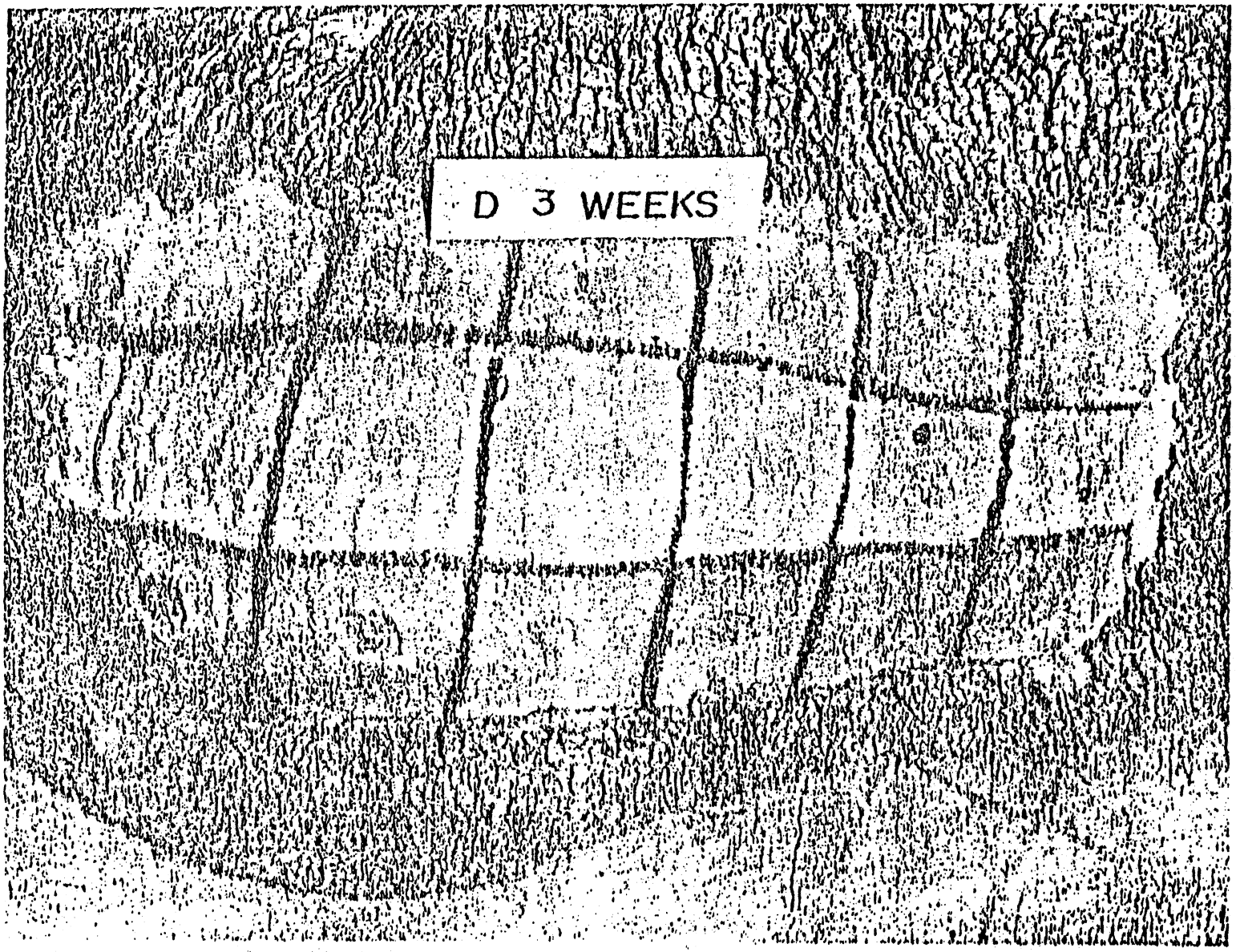
would require beta radiation of 2.2 mev in amounts in excess of 150,000 rep if applied to the wool surface and in excess of 15,000 rep if applied to the skin surface. Sheep wool is a good protector against beta irradiation.

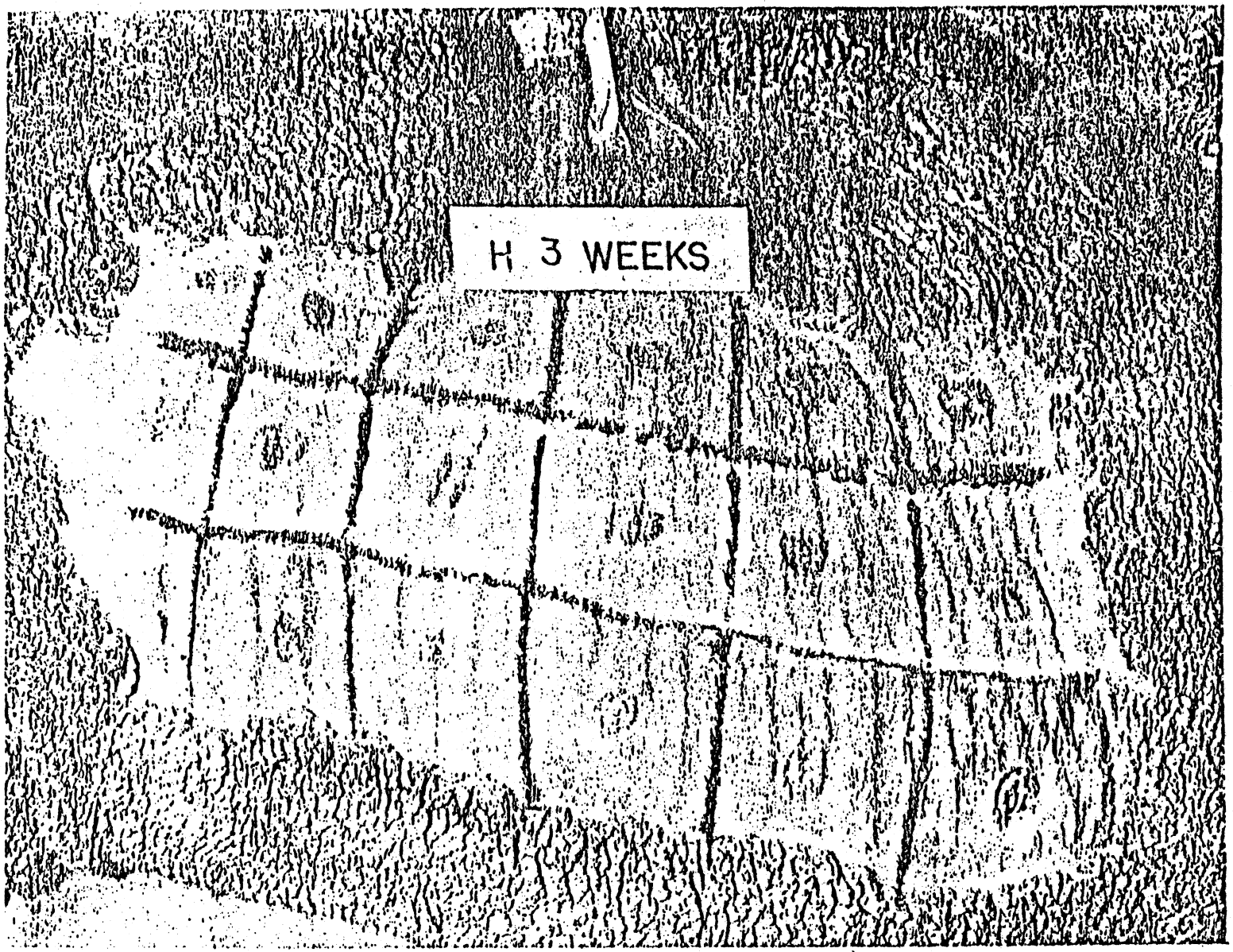
2. The lesions of the sheep in the field differ histologically, but not grossly, from so-called radiation burns by not having a gradation of degenerative changes in the epidermal appendages and not having any demonstrable typical vascular changes.

3. Lesions similar to those in the Cedar City sheep can be produced by physical and infectious agents which do not involve ionizing radiations.

Work done by:

C. C. Lushbaugh, M. D.
J. F. Spalding, Ph.D.
D. B. Hale, B. S.

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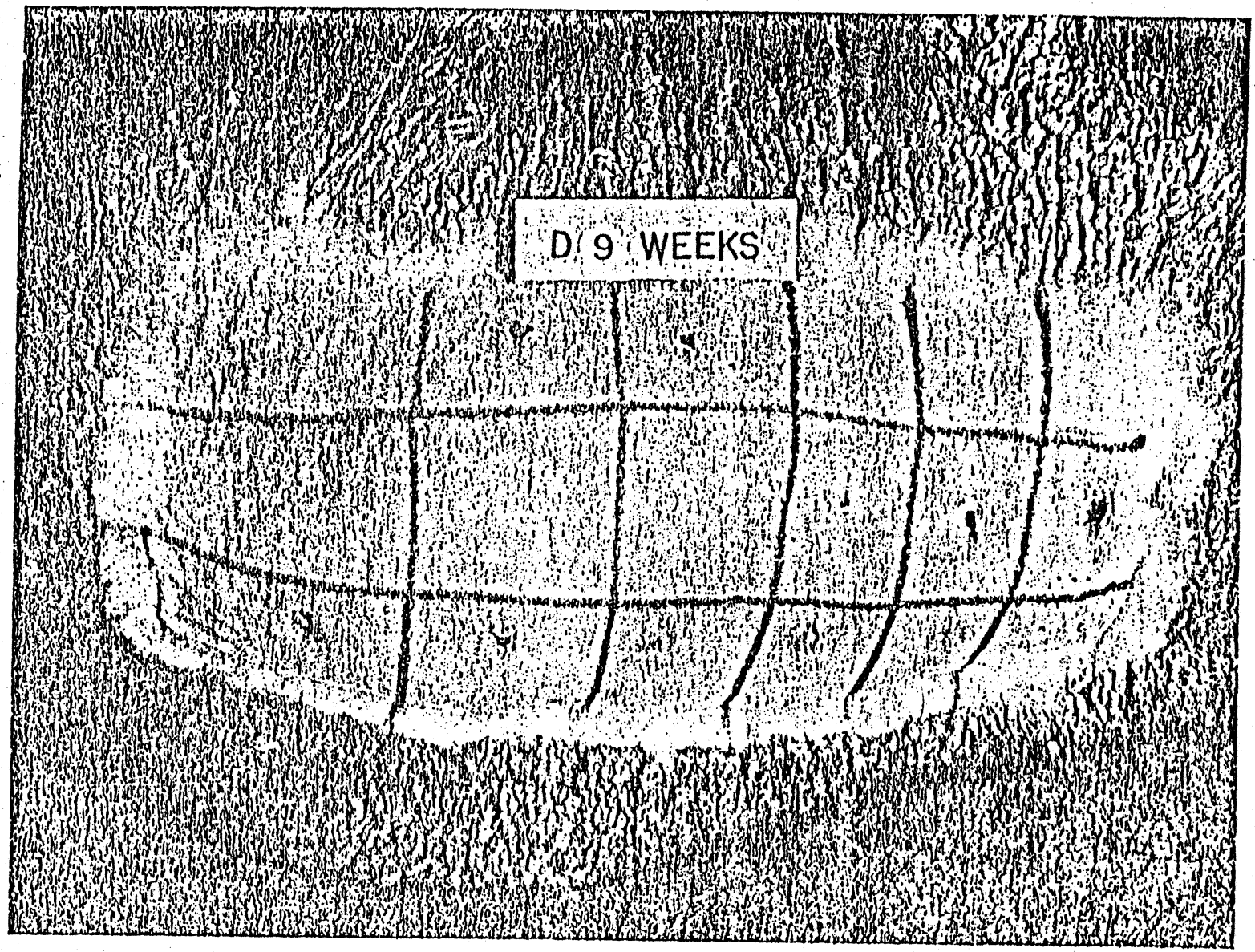
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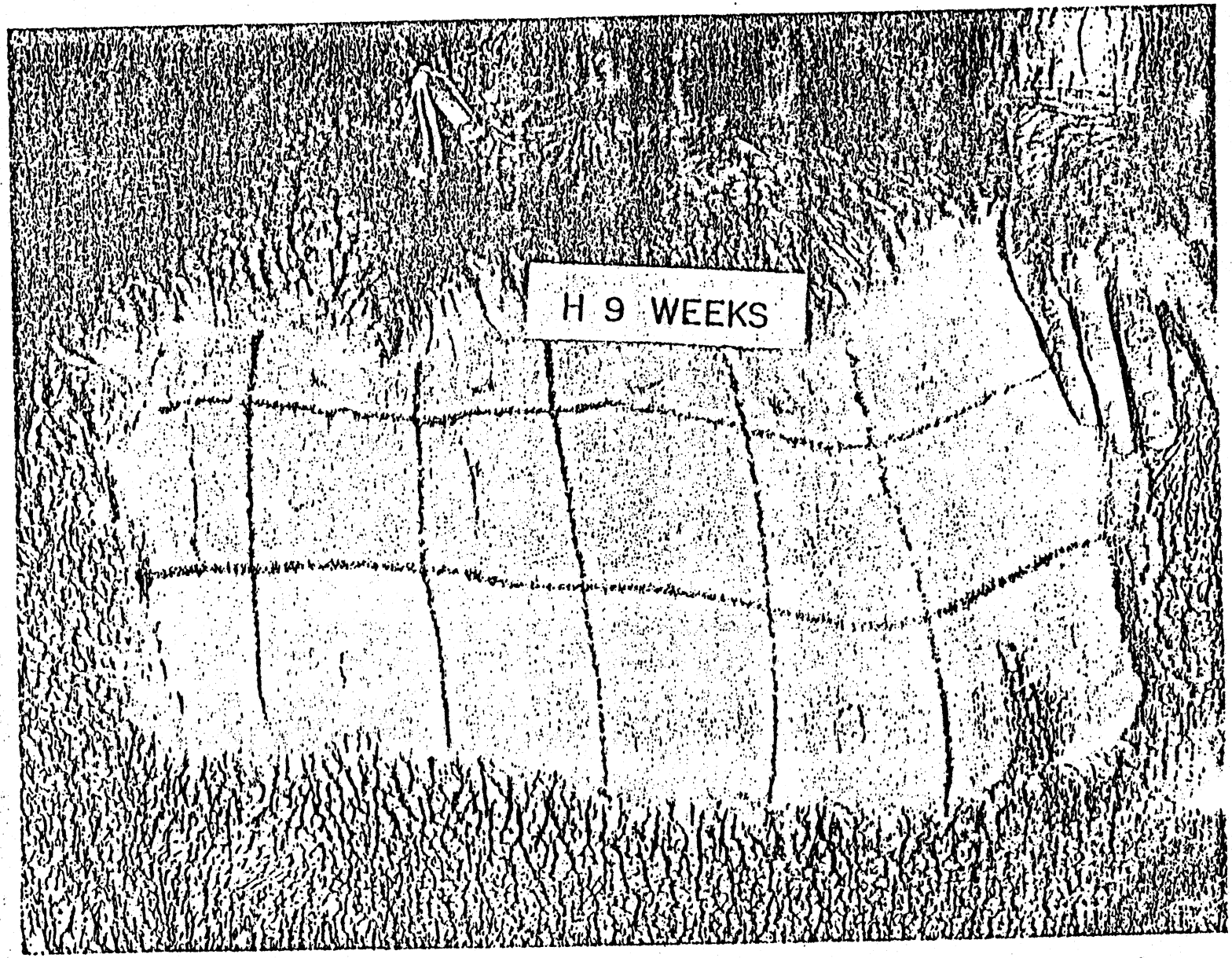

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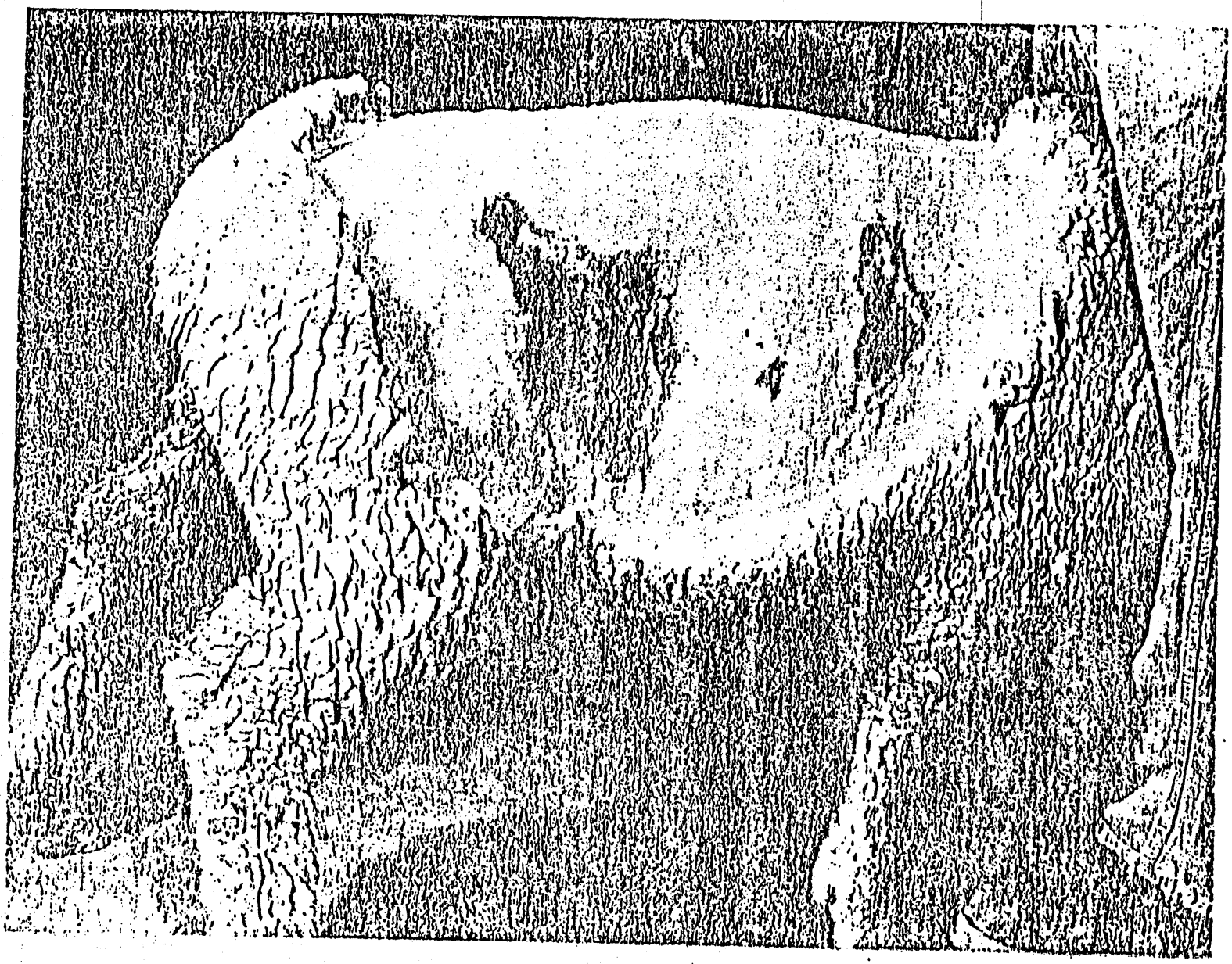
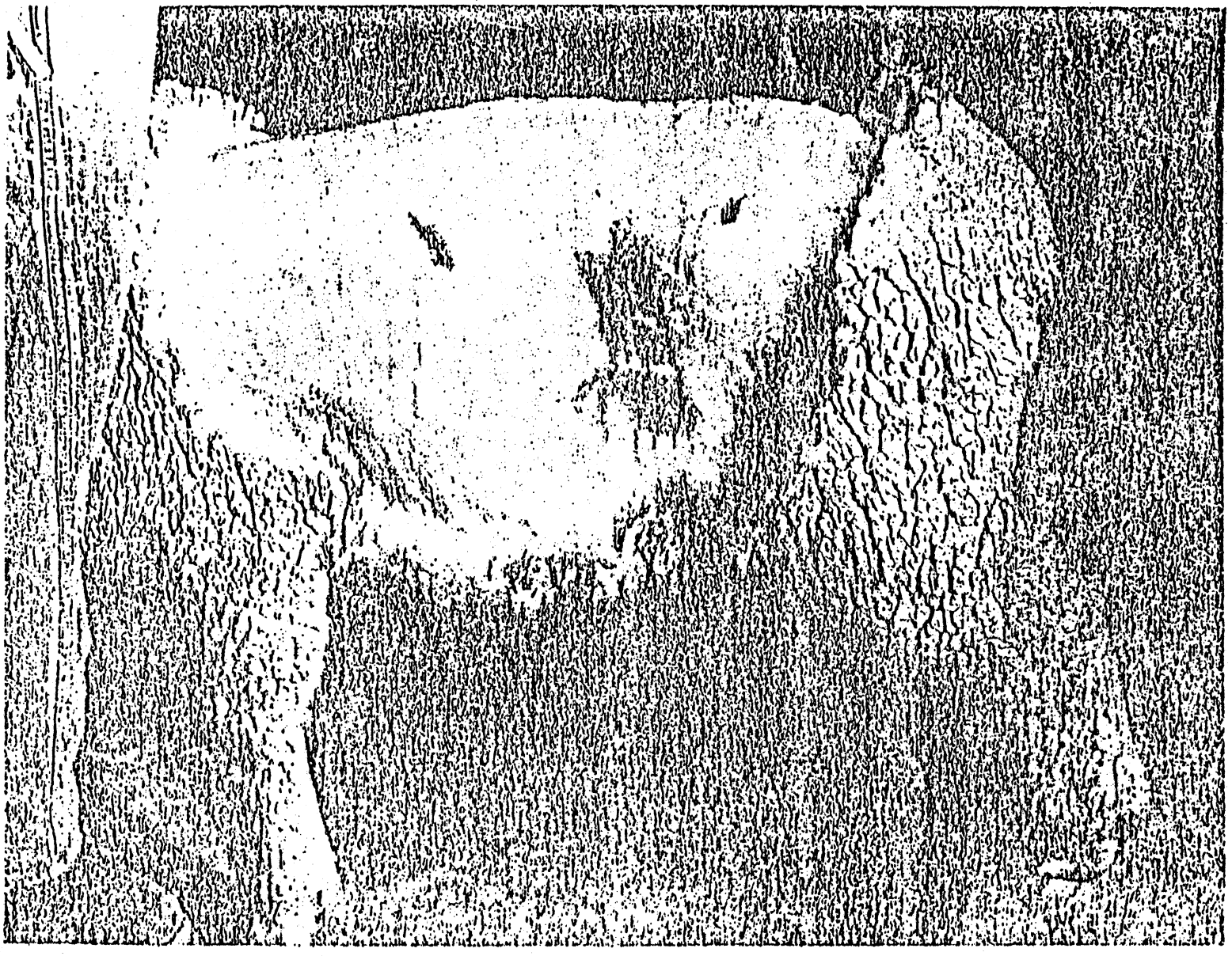
ATLAS OF THE GREAT LAKES





A COMPARATIVE STUDY OF HANFORD AND UTAH RANGE SHEEP

by

L. K. Bustad, S. Marks, N. L. Dockum, D. R. Kalkwarf and H. A. Kornberg

Biology Section

Radiological Sciences Department

November 30, 1953

HANFORD ATOMIC PRODUCTS OPERATION

RICHLAND, WASHINGTON

A COMPARATIVE STUDY OF HANFORD AND UTAH RANGE SHEEP

L. K. Bustad, S. Marks, N. L. Dockum, D. R. Kalkwarf, and H. A. Kornberg

ABSTRACT

Observations on sheep representing flocks in Utah adjacent to the Nevada Proving Ground were compared with findings made on experimental sheep exposed to various amounts of radioiodine. The Utah sheep showed no evidence of the radiation damage observed in experimentally treated sheep. Estimations of amounts of radioiodine on vegetation required to cause serious thyroid damage following a contamination event are included.

INTRODUCTION

This paper relates gross and microscopic observations on Utah sheep to observations made over a four-year period by the Biology Section on sheep exposed locally to I^{131} and their controls. The data from Utah sheep are based on tissues taken at autopsy from seven sheep representing three different flocks which incurred heavy losses following arrival at Cedar City, Utah from the environs of the Nevada Proving Grounds. Information was also obtained from various reports (1,2) of observations made on animals near the test site.

Data gained locally are derived from a continuing experiment which was initiated at the Experimental Animal Farm early in 1950 to define the toxicity of radioactive iodine. Since this radioactive isotope is one of the principal by-products of atomic fission of possible critical importance, it is of major concern potentially in the fall-out of atomic detonations and in the disposal of gaseous wastes from plutonium production. Following its emission from stacks of chemical separations plants, it may fall to the ground, contaminating the vegetation which may be eaten by man or by grazing animals. Since the principal grazing animals in the environs of the Hanford Plant are sheep, they were the animals chosen for the main experiment. The primary objectives of the experiment were 1) to determine

the permissible concentration of I^{131} on vegetation contamination stack effluent, 2) to define the pathological syndrome of various toxic levels of radioiodine in both growing and adult sheep, and 3) to improve the evaluation and control of hazards to personnel from exposure to radioactive isotopes by extrapolation from large animal work.

Although details of the experiments are available elsewhere (3,4) a brief summary of the methods applied together with a summary of experimental observations of immediate comparative applicability is included in this report. Purebred Suffolk sheep from the local range were used in this study. Dietary constituents were purchased locally in order to simulate range conditions of the Plant environs. Because of the low iodine content of the vegetation, the surrounding area is classified as marginally goitrogenic. The intake of iodine was restricted in order to have a maximum uptake of I^{131}. The carrier-free radioactive iodine was administered daily in a drilled feed pellet.

The number of animals in each group and the amount of I^{131} fed each day at the initiation of the main experiment on April 18, 1950, were as follows:

TABLE 1

Amount of I^{131} Fed and Number of Sheep

μc I^{131} fed/day	1800	240	5	0.15	0.005	Control Project	Control Off-Project
Number of sheep	3	12	12	24	24	24	20

When ewe lambs reached weaning age (four months), representative numbers were placed on the same I^{131} regimen as their dams. After satisfactory definition of the radiation syndrome in the 240 μc/day and 1800 μc/day groups, I^{131} feeding of these animals was terminated at 450 and 420 days, respectively, and intermediate groups of yearling ewes were initiated at 15, 30, 45, and 135 μc/day feeding amounts.

In addition to the main study, supplemental experiments were performed in order to correlate thyroid damage and biochemical changes with radiation dose. Sixteen young adult rams were fed 480 uc/day and killed at various periods after the initiation of the experiment. Single high doses were administered to two young adult rams together with a large number of single tracer doses applied to young adult animals.

Periodically, blood samples were collected from all ewes. Hematological procedures included erythrocyte, leukocyte and differential counts and hemoglobin determinations. In addition, blood chemical determinations for calcium, acid-soluble phosphorus, creatinine, NPN (non-protein nitrogen), total protein, albumin-globulin ratio, total cholesterol, alkaline phosphatase and glucose were performed. After the first eight months of the experiment the tests made were reduced to leukocyte count, hemoglobin determination, creatinine and PBI (protein-bound iodine) analyses. However, frequency of sampling of blood was increased on supplemental studies and radiometric PBI was determined in animals fed 5 or more μc/day. Specimens of blood, feces and urine were submitted periodically for assay of activity densities. Routine sampling of tissues for radiochemical analysis was performed at autopsy.

Complete necropsies and histological examinations were made on all expired animals and on representative numbers of lambs at birth and at weaning. All on-project animals were sheared semi-annually and the quantity and quality of fleece determined.

CLINICAL DATA

The thyroid is considered the critical organ in radioiodine toxicity. This gland in an adult sheep will effect concentrations from 1,000 to 10,000 times that of the blood with definite indications of even a greater concentration in the

lamb. It was found by experimental monitoring (5) that the th[illegible]id of a sheep on a low stable iodine intake concentrates up to 60 per cent of a single tracer dose of I^{131} which decays with an effective half-life of about five days (biological half-life of about 14 days). However, the presence of recommended levels of iodized salt in the diet of sheep will result in only 10 to 30 per cent uptake of single tracer doses. On the other hand, in subacute and chronic studies involving the administration of I^{131} at levels of 135, 240, 480 and 1800 µc/day the thyroid uptake may not be as great as with lower levels in single tracer doses. Uptake values of about 30 per cent and an effective half-life of five days or biological half-life of 14 days are reasonable figures to apply in calculations with these higher dosage values until the thyroid is damaged. In chronic feeding, seasonal changes occur with the highest content of I^{131} in the thyroid observed from October to January and about one-half of the highest values observed in April to July.

Weight Changes

All young adult rams in a subacute study fed 480 µc of I^{131}/day gained weight during the five months of the study. A ram lamb fed a single dose of 280,000 µc of I^{131} and sacrificed six weeks later also showed a weight gain.

There was no significant weight difference noted during the first three years in any group of ewes fed from 0 to 240 µc of I^{131}/day. Individual animals, however, showed weight losses prior to death as a result of systemic disease or chronic wasting disease complicating the hypothyroid syndrome.

The lambs born to ewes fed 240 µc/day during the latter half of gestation of the first lambing season were normal in size. However, in subsequent lambing seasons in this group a significant reduction in birth weight of lambs occurred.

Blood Chemistry and Hematology

Control values for all blood parameters investigated and found to be definitely affected following the administration of high levels of radioiodine appear in Tables 1 and 2.

TABLE 1

Normal Hematological Data

	Leukocyte count $10^3/mm^3$	Lymphocyte count $10^3/mm^3$	Neutrophil count $10^3/mm^3$
Control Adult	8 - 12	5.5 - 8	3 - 4
Control Lamb (3 mos. old)	8 - 12	6.5 - 8.5	2.5 - 3.7

TABLE 2

Normal Blood Chemical Data

	Serum Calcium mg/100 ml	Serum Inorganic Phosphorus mg/100 ml	Apparent Serum Creatinine mg/100 ml	P.B.I.
Control Adult	10 - 13	4.8 - 5.5	0.9 - 1.4	2 - 4
Control Lamb (3 mos. old)	11 - 14	6.2 - 6.6	1.0 - 1.6	3 - 6

Protein-bound iodine values fall below 2 µg/100 ml, apparent creatinine values increase to over 1.5 mg/100 ml, and absolute lymphocyte counts may fall below 4,000/mm^3 when the thyroid has received enough radiation to destroy its ability to concentrate iodine. This applied to high subacute and chronic feeding levels. Concomitant with reduction in PBI levels, inorganic I^{131} values were shown in subacute studies to be higher than protein-bound I^{131} values. In addition serum calcium values fall and serum inorganic phosphorus values rise about five months

following thyroid damage of a severity sufficient to cause defini pothyroidism.

Reproduction

No decrease was noted in the number of ewes that conceived in any group, including three ewes fed 1800 μc of I^{131} daily for 450 days.

Administration of I^{131} in the chronic study at the Experimental Farm began when the ewes were in the latter one-half of gestation. In the group fed 240 μc/day, the first-year lambs were normal in size and appearance. The lambing ratio was 1.7 in this group, and there was no increase in mortality noted during the weaning period compared with controls.

There was no increase in the incidence of abortion in any group fed radioactive iodine.

Clinical Observations

No clinical effects were observed prior to the development of serious damage to the thyroid gland in any experimental animal fed daily amounts of I^{131} ranging from 0.005 μc/day to 1800 μc/day. However, the ram lamb fed 280,000 μc of I^{131} in one dose in an acute study showed a transient swelling in the upper cervical region shortly after isotopic administration. Clinical evidence of damage was observed in subacute and chronic studies three months or more following thyroid ablation.

The findings previously described (3) as associated with I^{131} toxicity in the adult sheep are lethargy, muscular weakness, clumsy motion, constipation, dry skin and fleece, and a diminution of milk secretion. In addition, lambs rendered athyroid show a marked reduction in growth and some abnormal skull growth that results in difficulty in mastication and subsequent ulceration on the tongue and cheeks. A variable hair loss may also be observed in the young animals.

GROSS PATHOLOGY

Although the thyroid is relatively radio-resistant, structural and functional damage appears first in this gland because of the great differential in I^{131} concentration it exhibits when compared with other tissues.

A normal thyroid appears in Figure 1. Compared with this is an ablated gland (Figure 2) which consists of a nonfunctioning fibrous band, resulting from a radiation dosage greater than 70,000 rep in ten months of life. Similar destroyed thyroids are observed in any animal about five or more months after the gland fails to concentrate iodine. Gross effects of intermediate severity are observed in the thyroid if the dose is inadequate to destroy the gland or the time period is insufficient to allow complete replacement of damage epithelium by connective tissue. In such cases, glandular tissue may survive in the form of islands within a fibrous network. Foci of necrosis or calcification may impart a gritty consistency which is noted when the gland is incised. Mottling of the sectioned surfaces results from an irregular distribution of tissue damage.

Calcium plaques in the arteries and veins were often observed in sheep that were hypothyroid for an extended period. A gelatinous appearing edema fluid was also noted in the subcutaneous tissue of certain chronically hypothyroid sheep. Tracheal constriction was present in some athyroid lambs at birth (Figure 3).

Figure 3. Constriction of Trachea adjacent to the Thyroid in a newborn lamb whose dam was fed 240 μc/day.

MICROSCOPIC OBSERVATIONS

The histopathologic effects in the thyroid glands resulting from the administration of I^{131} are variable, depending upon the intensity and duration of the dosage (6,7). Mild subacute damage was observed in young adult rams after 19 days of feeding of 480 μc/day and a thyroid dosage of 16,000 rep. The initial damage consisted of the presence of foci of inflammatory infiltration, the cellular elements being lymphocytes and a few neutrophils (Figure 4). The follicles were damaged in the inflammatory areas and were subject to invasion by inflammatory cells. The involved areas were sharply localized, being surrounded by normal parenchyma. At a later date, the thyroid glands in this series showed diffuse edema and inflammation between follicles with fibrosis supervening subsequently (Figures 5 and 6).

Smaller dose levels led to pathologic effects only after prolonged periods of feeding of radioactive iodine, providing examples of the minimal pathologic effects to be expected as a consequence of exposure to minimally effective levels of I^{131}. Lambs exposed continuously to I^{131} from the time of fertilization in a dose of 5 μc/day administered by way of the mother and later administered directly showed edema between follicles as the only initial pathologic manifestation (Figure 7). Delicate fibrosis between the follicles was observed in adults fed 5 μc of I^{131} daily after a period of 33 months (Figure 8). No injury was grossly manifest in these animals.

The above histologic indications of minimal damage (localized foci of inflammation and follicular damage within the parenchyma and slight enema and fibrosis between the follicles) are to be regarded only as evidence of the presence of sufficient quantities of I^{131} in the thyroid gland to cause morphological effects. An exposure of the thyroid gland to I^{131} sufficient to have an effect on the health

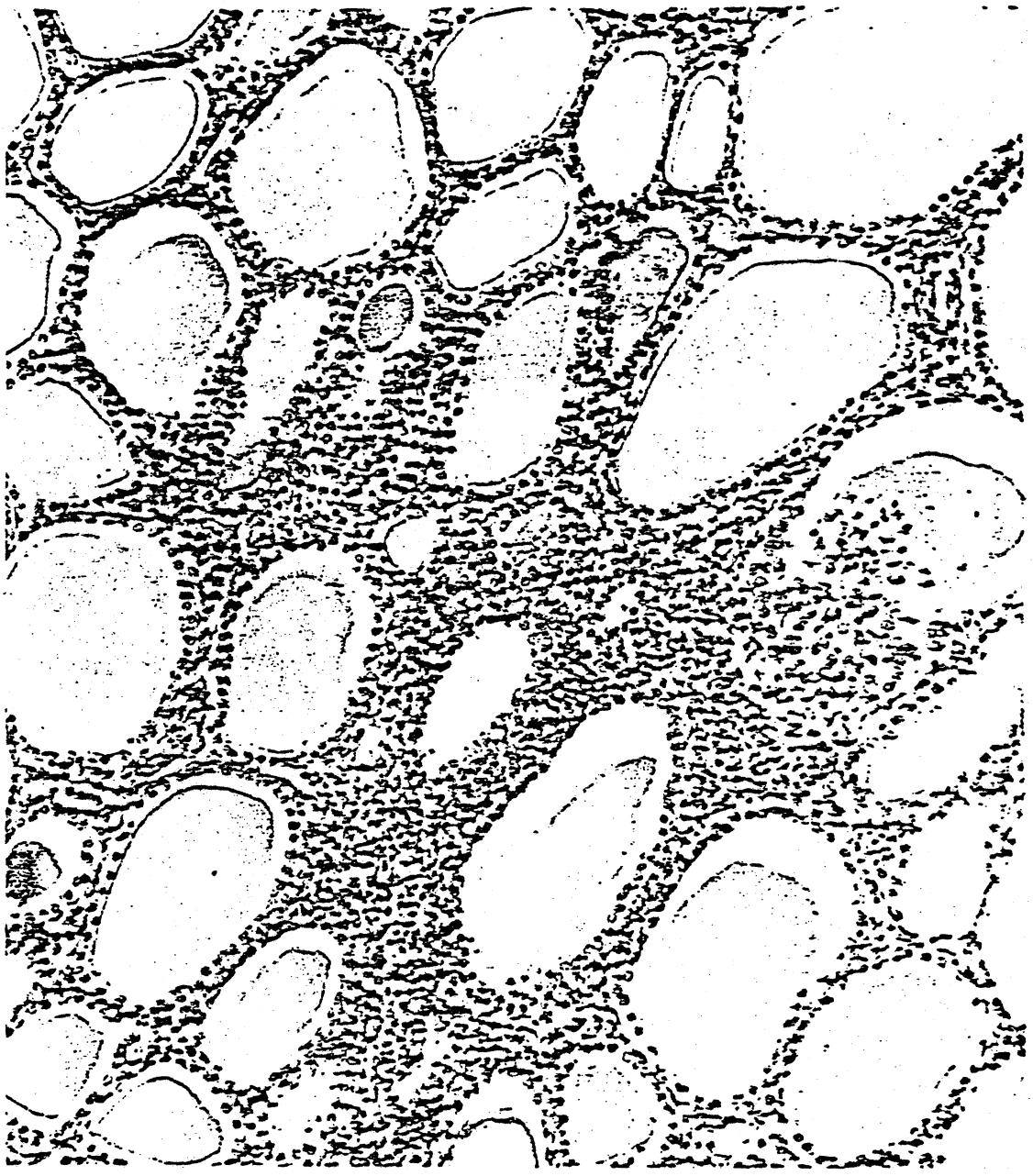


Figure 4. Early localized focus of inflammation with damaged Follicles in Thyroid of sheep fed 480 μc per day for 18 days (Radiation dose 16,000).

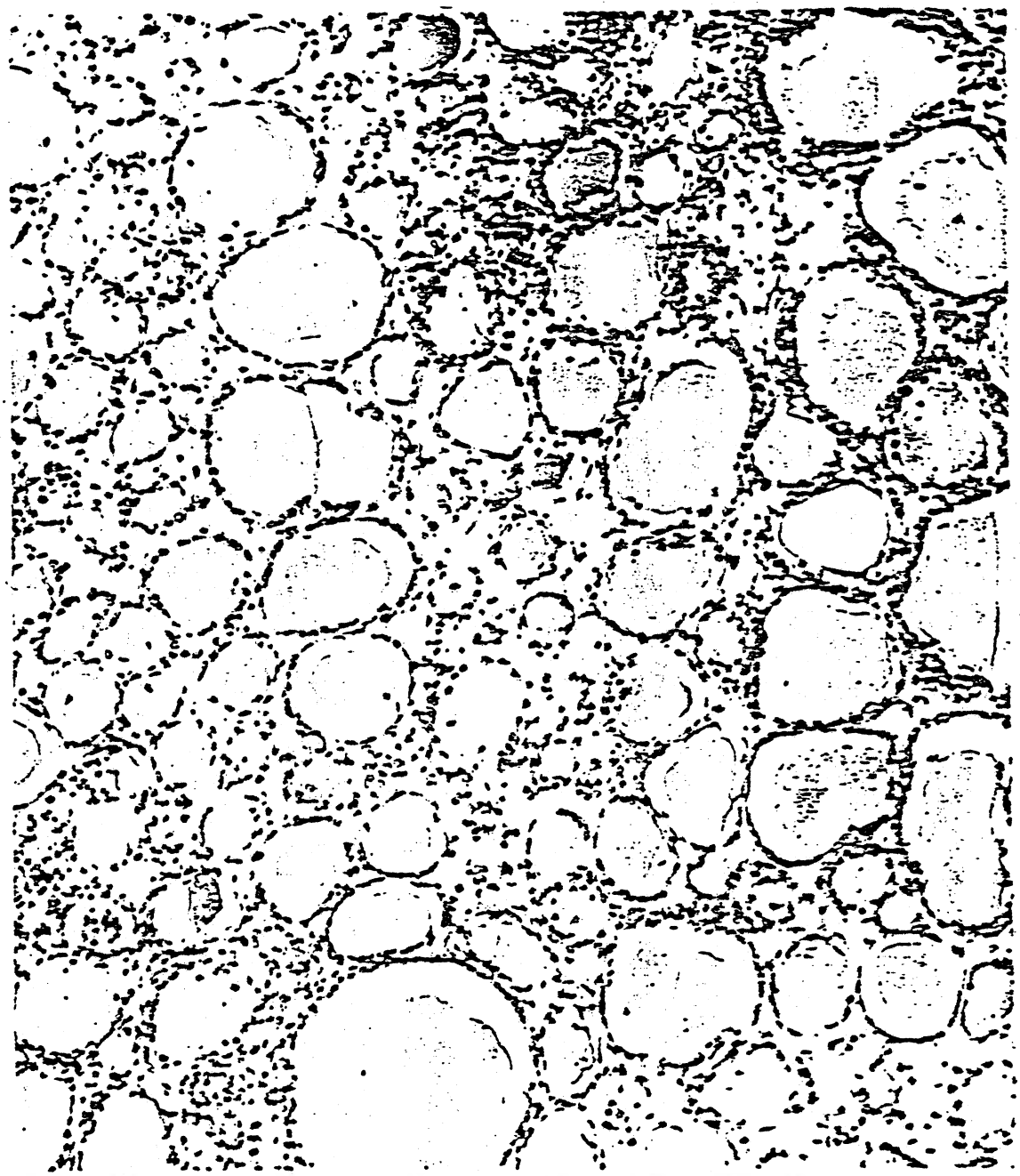


Figure 5. Generalized Edema and inflammation between Thyroid Follicles as a later effect in sheep fed 480 μc per day for 43 days (Radiation dose greater than 80,000 rep).

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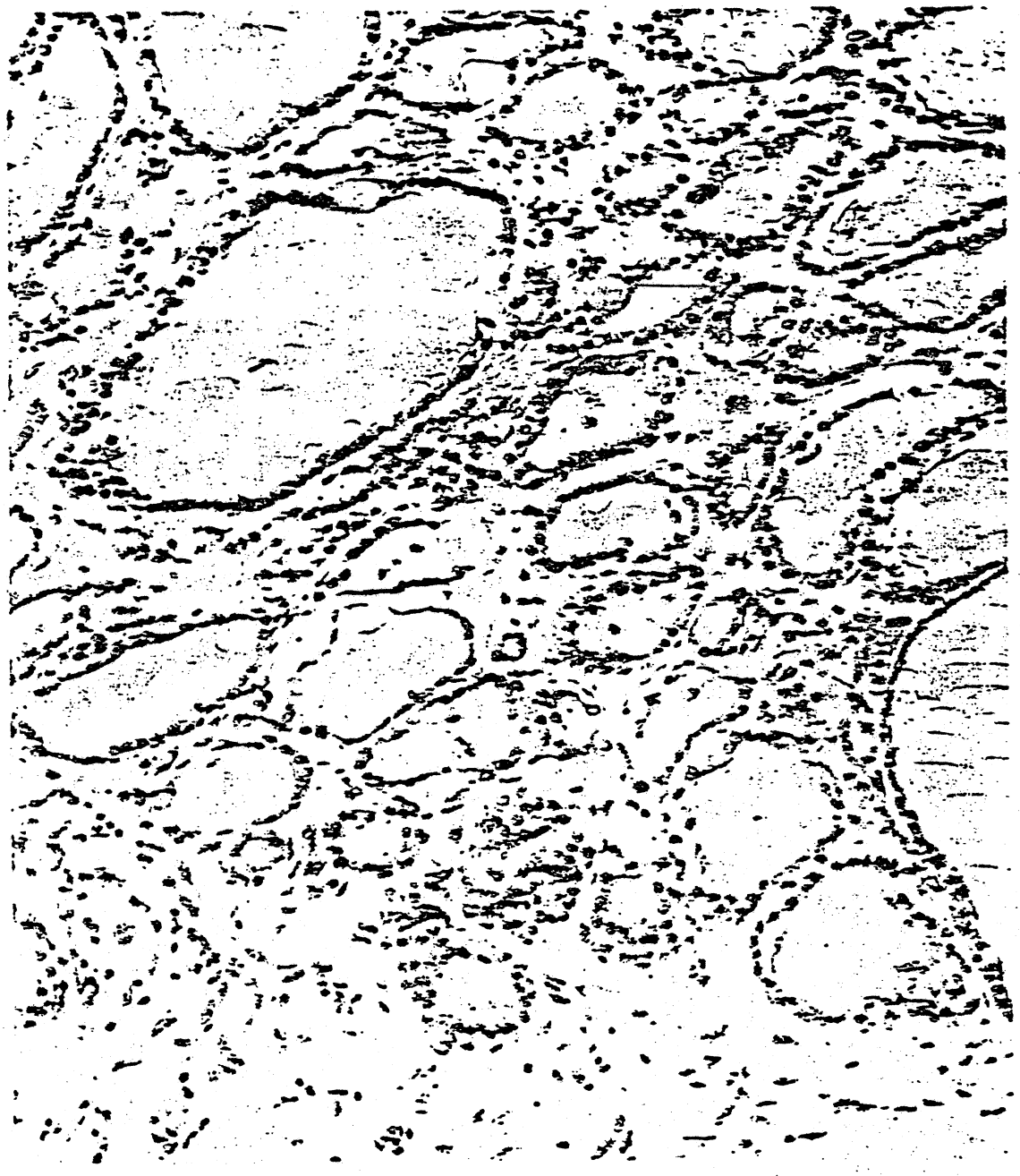

Figure 6. Fibrosis between Thyroid Follicles as later effect in sheep fed 480 μc per day for 106 days (Radiation dose about 150,000 rep).

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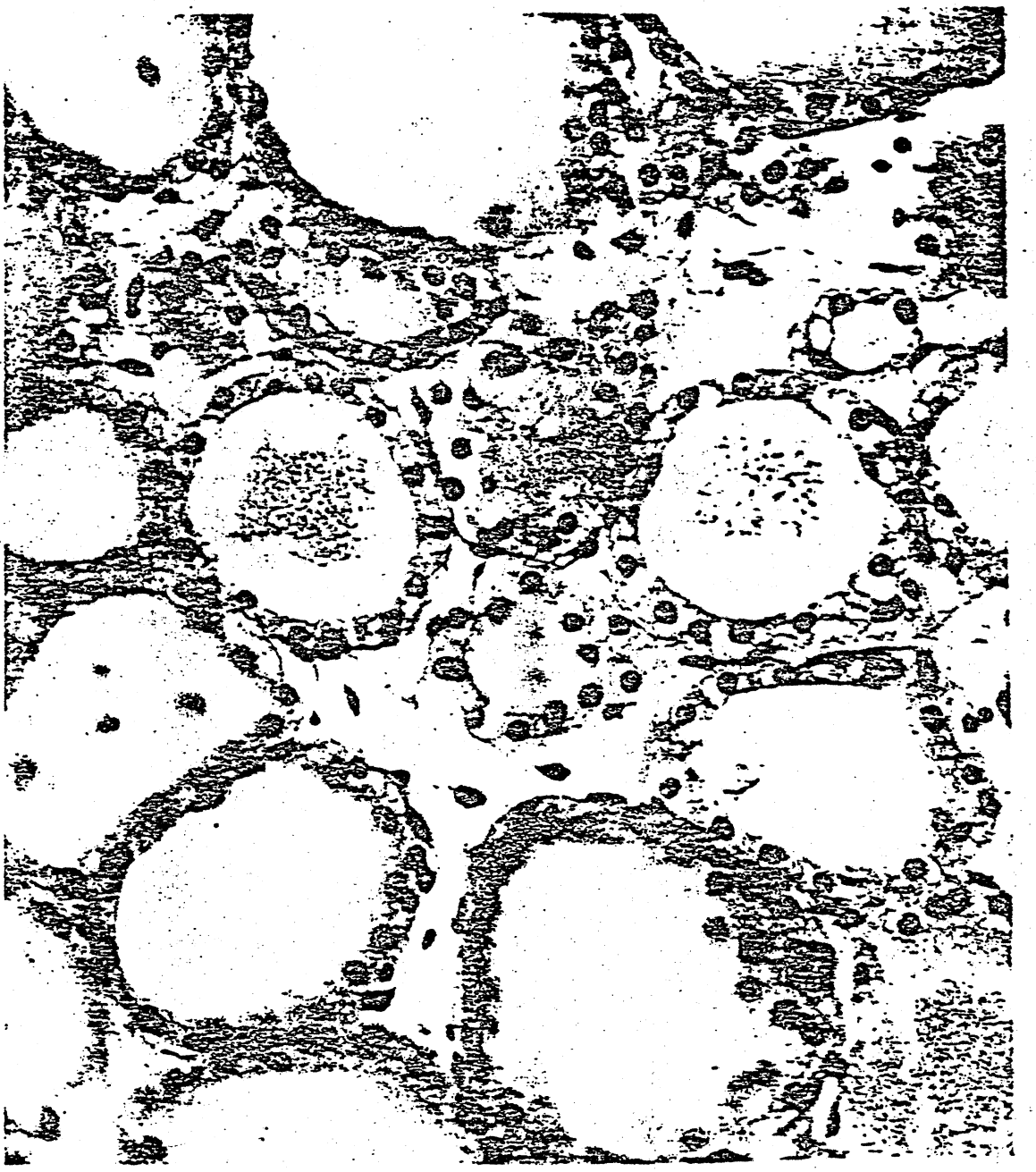

Figure 7. Slight Edema between Follicles in 14 month old ewe fed 5 μc/day for 10 months following weaning from a dam fed 5 μc/day.

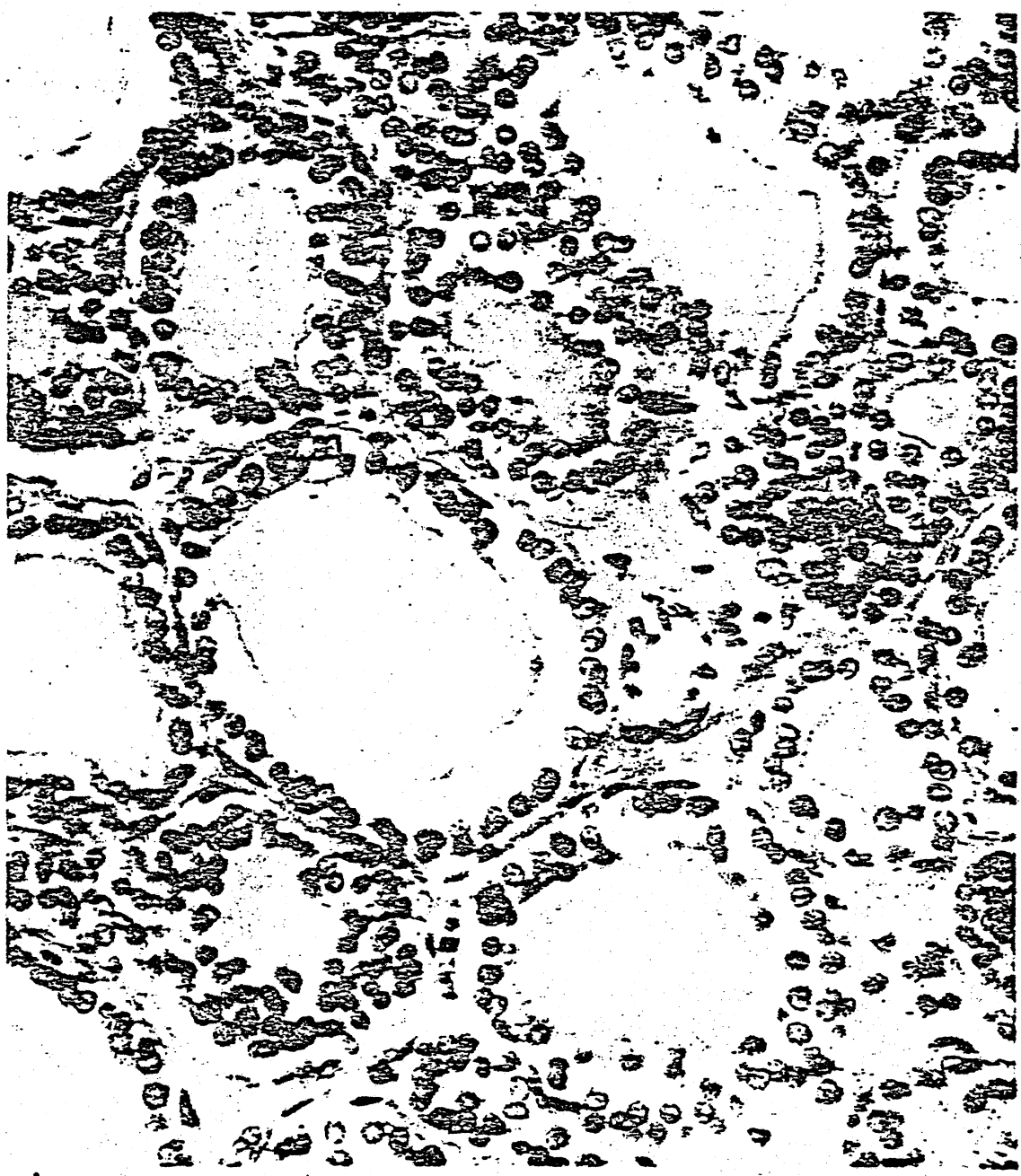

Figure 8. Minimal Fibrosis between Follicles in adult ewe maintained on daily feeding of 5 μc of I^{131} for 32 months (Radiation dose greater than 35,000 reps).

of the total organism is invariably accompanied by histologic damage of a more severe degree. A single massive feeding of 280,000 μc of I^{131} caused a complete necrosis of the thyroid gland with no evidence of surviving viable epithelium (Figure 9). At the time of sacrifice, six weeks after the feeding, this animal was alive and in good clinical condition.

Deaths in the exposed groups usually resulted from infections such as pulmonary abscesses complicating the syndrome of hypothyroidism, which developed at least several months after the onset of exposure. Figure 10 illustrates severe fibrosis with marked distortion and reduction in size of follicles in the center of the gland occurring in a lamb of the group fed 240 μc/day from weaning until an age of eight months when it was sacrificed. The section illustrates the usual tendency for damage of greatest severity to be concentrated in the center of the gland and the relative sparing of the periphery. This effect is attributed in part to the cross-fire of radiation encountered at sites entirely surrounded by parenchyma. Figure 11 shows an almost complete replacement of thyroid tissue by a hyalinized scar in a clinically hypothyroid animal fed 1800 μc/day for five months. The thyroid in this animal failed to pick up iodine after the 15th day and a thyroid dosage of 50,000 rep. The onset of symptoms of hypothyroidism occurred several months after the administration of I^{131} was started. The scar stands in contrast to the adjacent viable parathyroid tissue.

Utah Sheep Thyroids

The thyroid sections made available by Lt. Col. Veenstra on six Cedar City sheep showed a general absence of damage to the parenchyma (Figures 12 to 23). Photomicrographs of thyroid glands of Experimental Animal Farm control sheep have been included for purposes of comparison with representative areas from Utah sheep thyroids. There was no evidence of edema, fibrosis or inflammation

Figure 9. Complete Necrosis of Epithelium providing appearance of ghost Follicles, six weeks after a single dose of 280,000 μc of I^{131} (Radiation dose greater than 100,000 rep in 3 days).

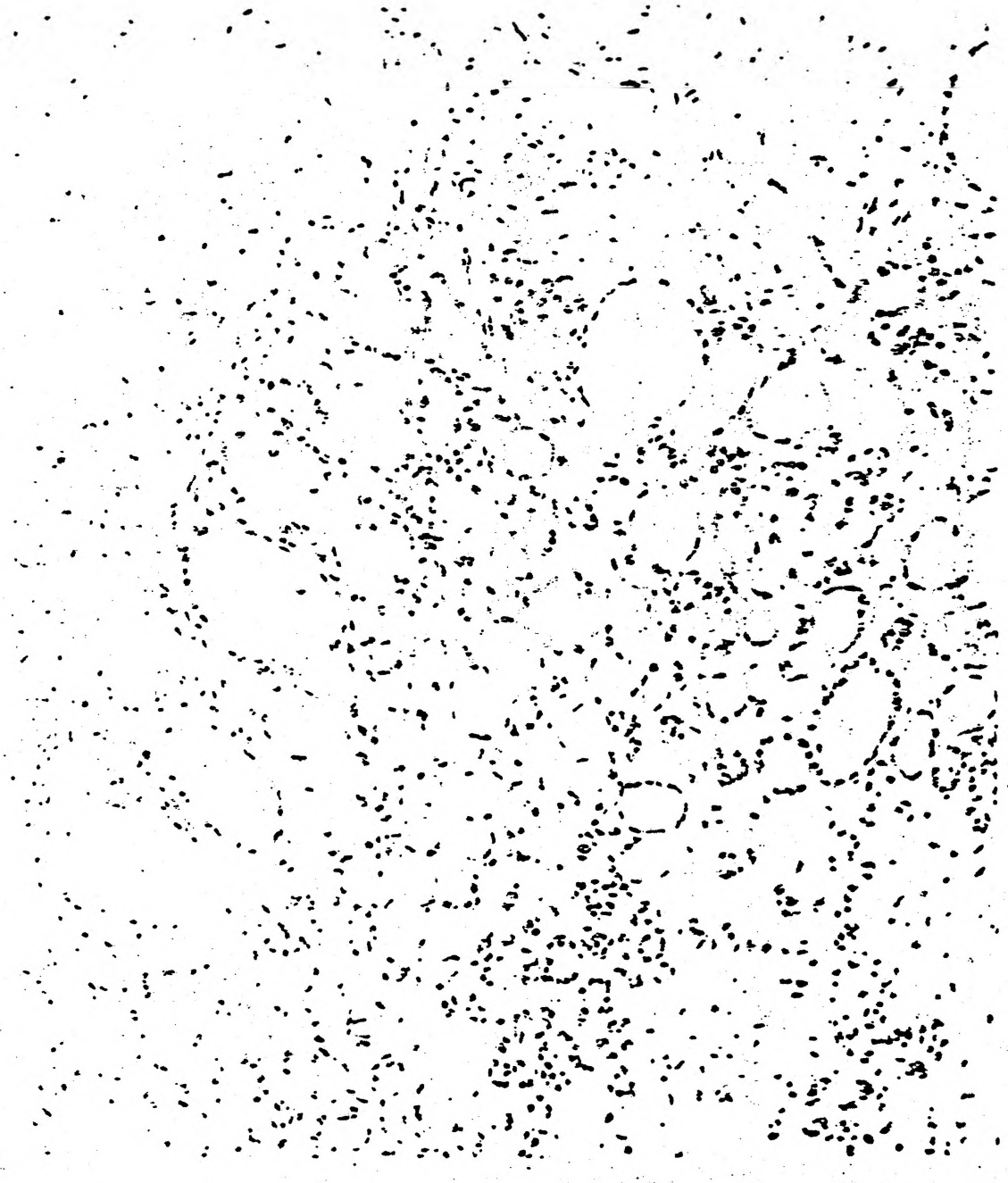

Figure 10. Severe Fibrosis in gland with reduction in size of Follicles. Illustrates greater severity of damage in central portion of gland (Lower right). This eight-month old lamb was fed 240 µc/day after weaning from a ewe fed 240 µc/day (Radiation dosage probably greater than 100,000 rep considering in Utero exposure).

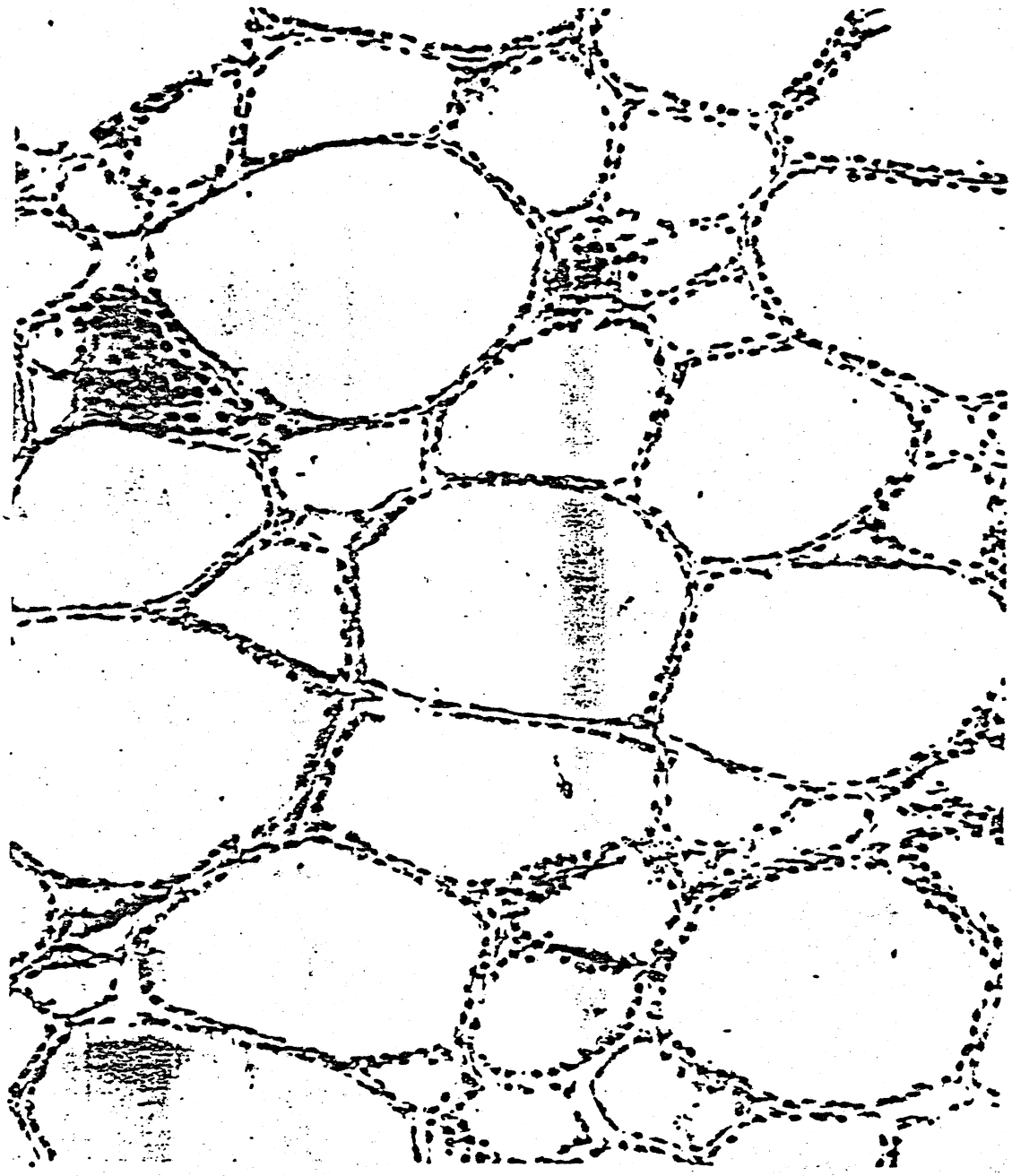

Figure 16. Thyroid Gland from Utah sheep #3. Large Follicles with low Epithelium. Clefts between Follicles represent Artefacts.

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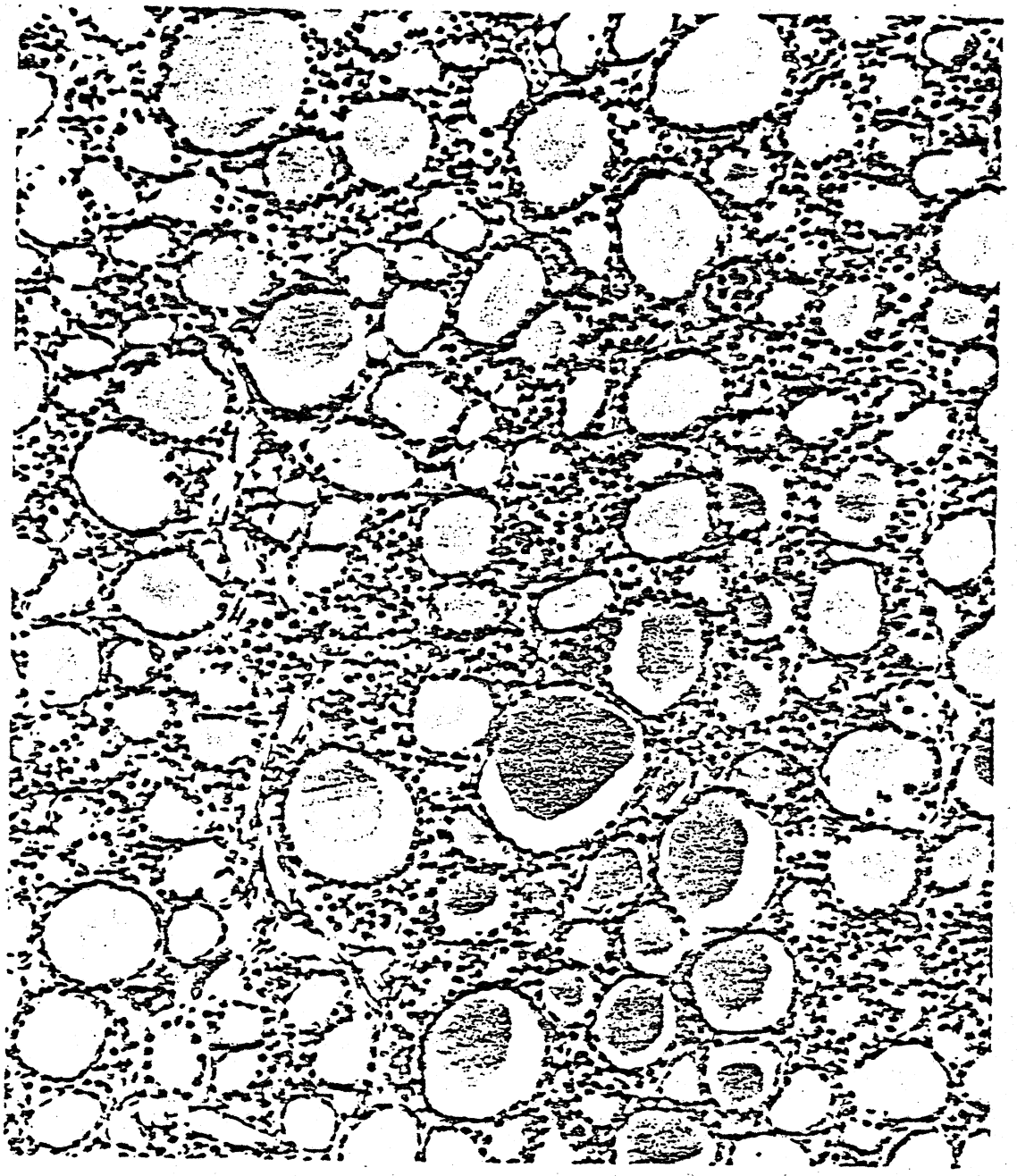

Figure 14. Thyroid Gland from Utah sheep #1. Small Follicular Pattern.

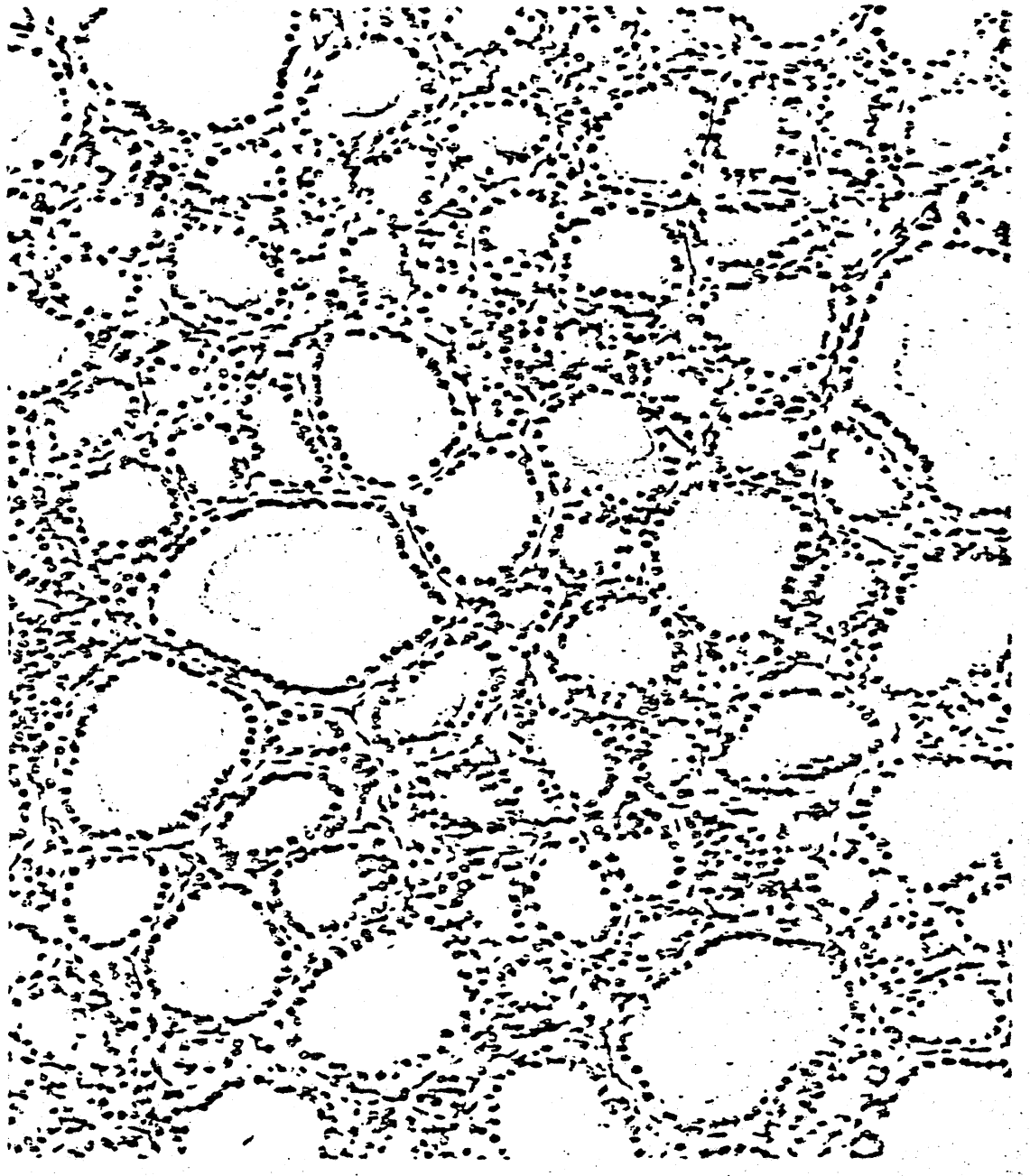

Figure 15. Thyroid Gland from experimental animal farm control sheep 24-20. Compare with Figure 14.

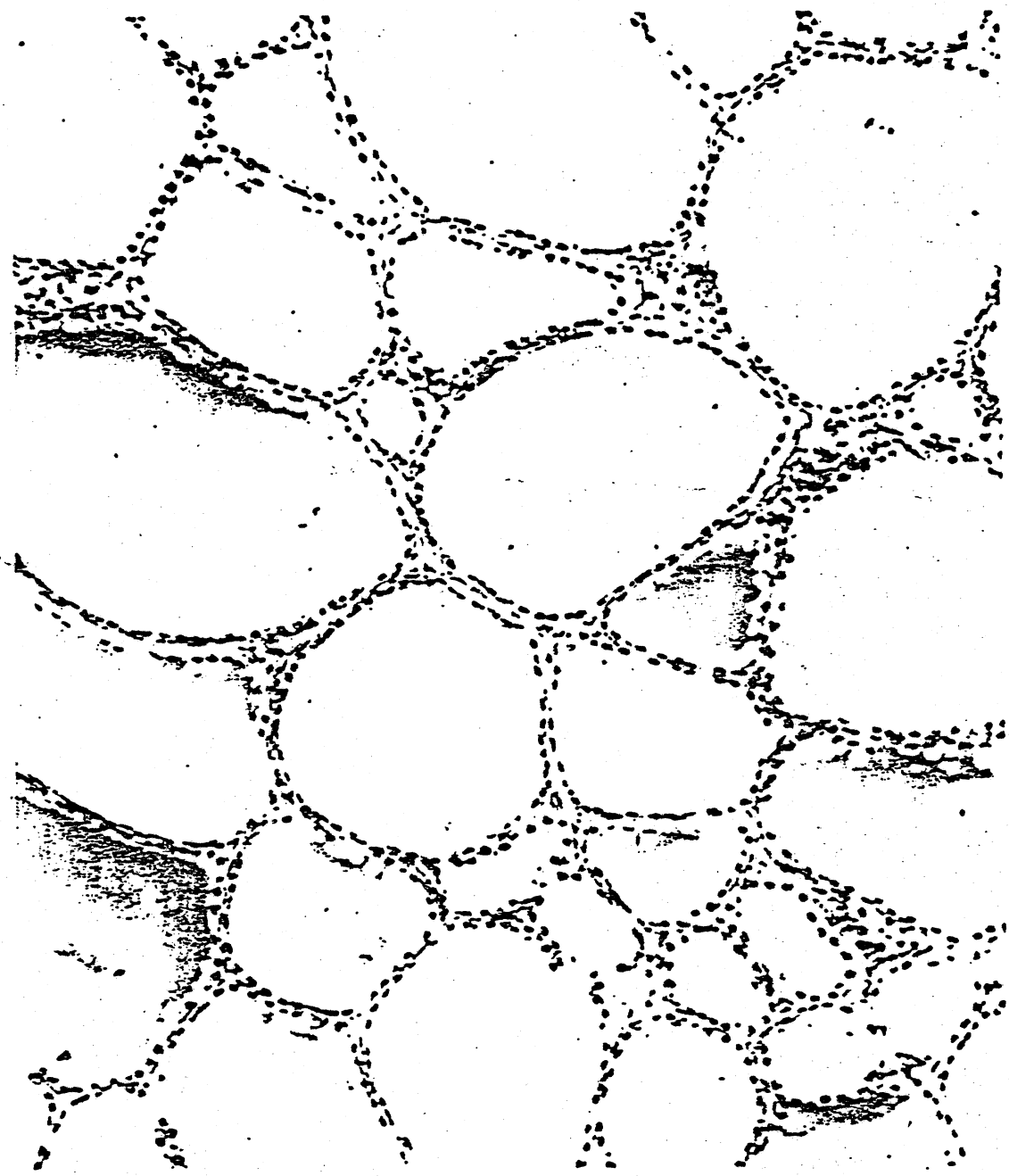

Figure 12. Thyroid Gland from Utah sheep #5. Large Follicles with low Cuboidal Epithelium and Peripheral Vacuoles in Colloid.

A.E.C. - G.E. - RICHLAND, WASH.

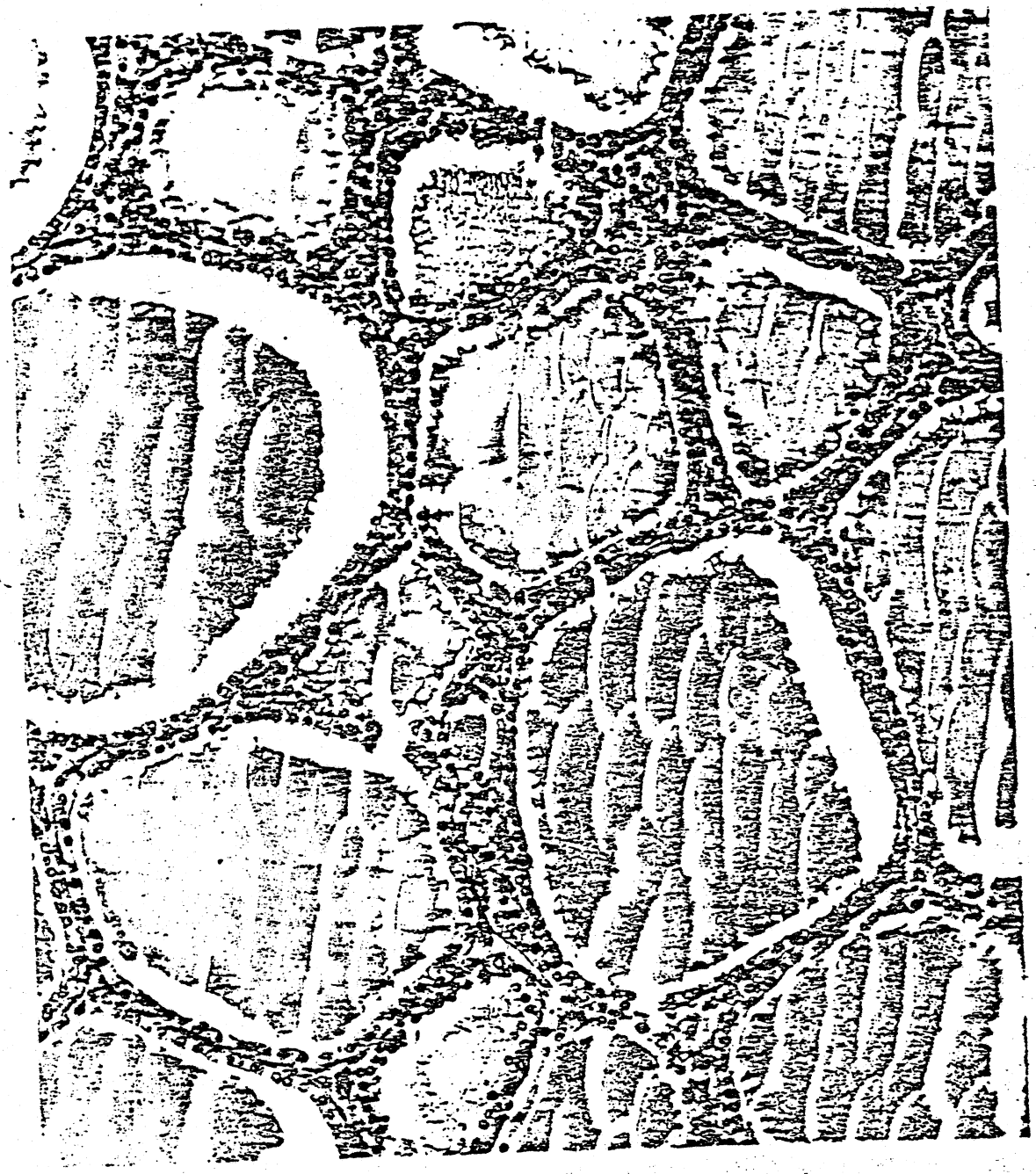

Figure 13. Thyroid Gland for experimental animal farm control sheep 14-12. Compare with Figure 12.

A.E.C. - G.E. - RICHLAND, WASH.

Figure 11. Scar remaining at site of destroyed Thyroid gland. Radioresistant Parathyroid tissue in Periphery of Thyroid remains viable. Sheep fed 1800 μc for five months (Radiation dose greater than 50,000 rep in first 15 days after which Thyroid failed to concentrate iodine).

Figure 17. Thyroid Gland from experimental animal farm control sheep 15-19
Compare with Figure 16.

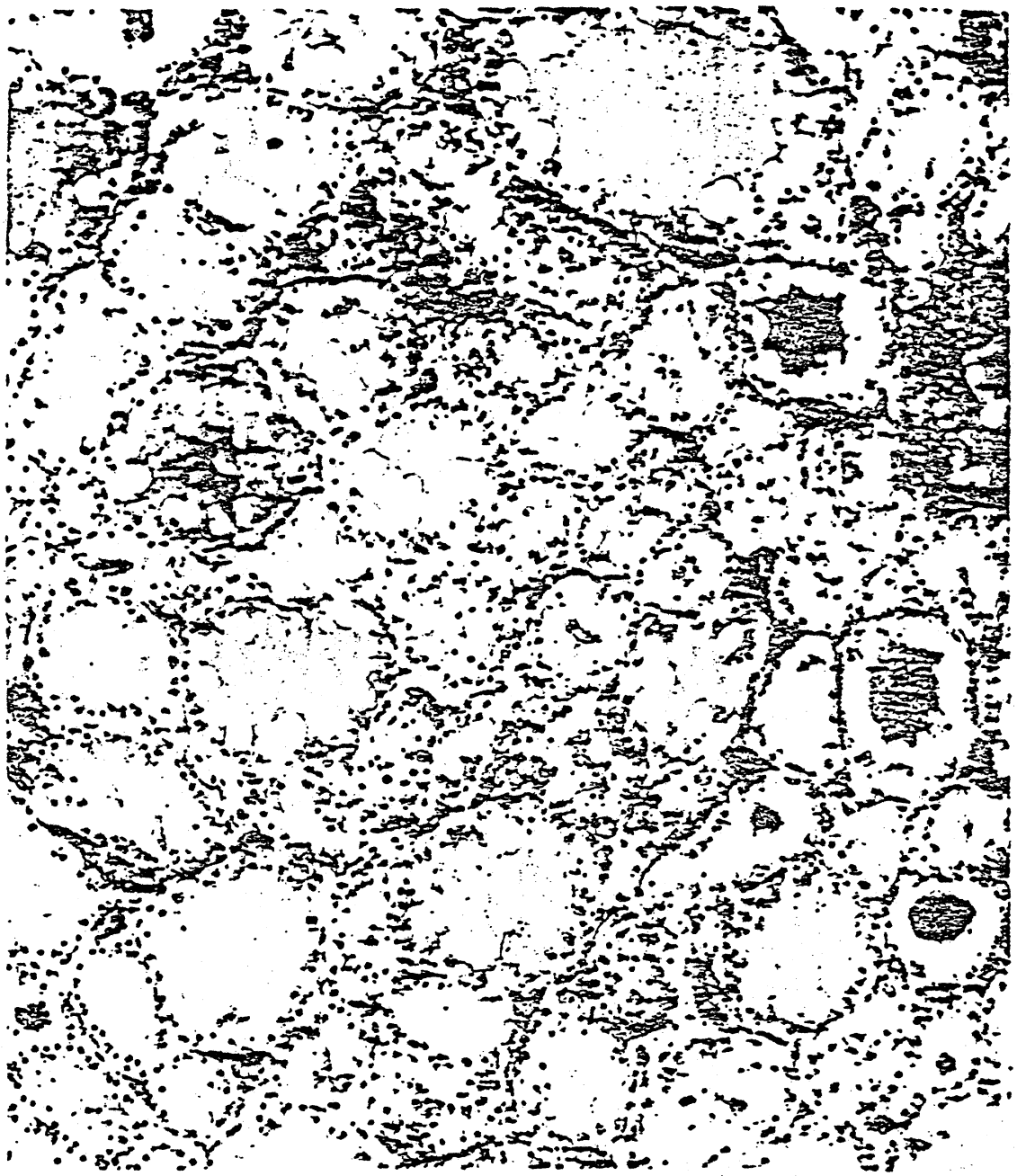

Figure 18. Thyroid Gland from Utah sheep #1. Severe postmortem Autolysis with Pyknosis of Nuclei and disorganization of Follicles.

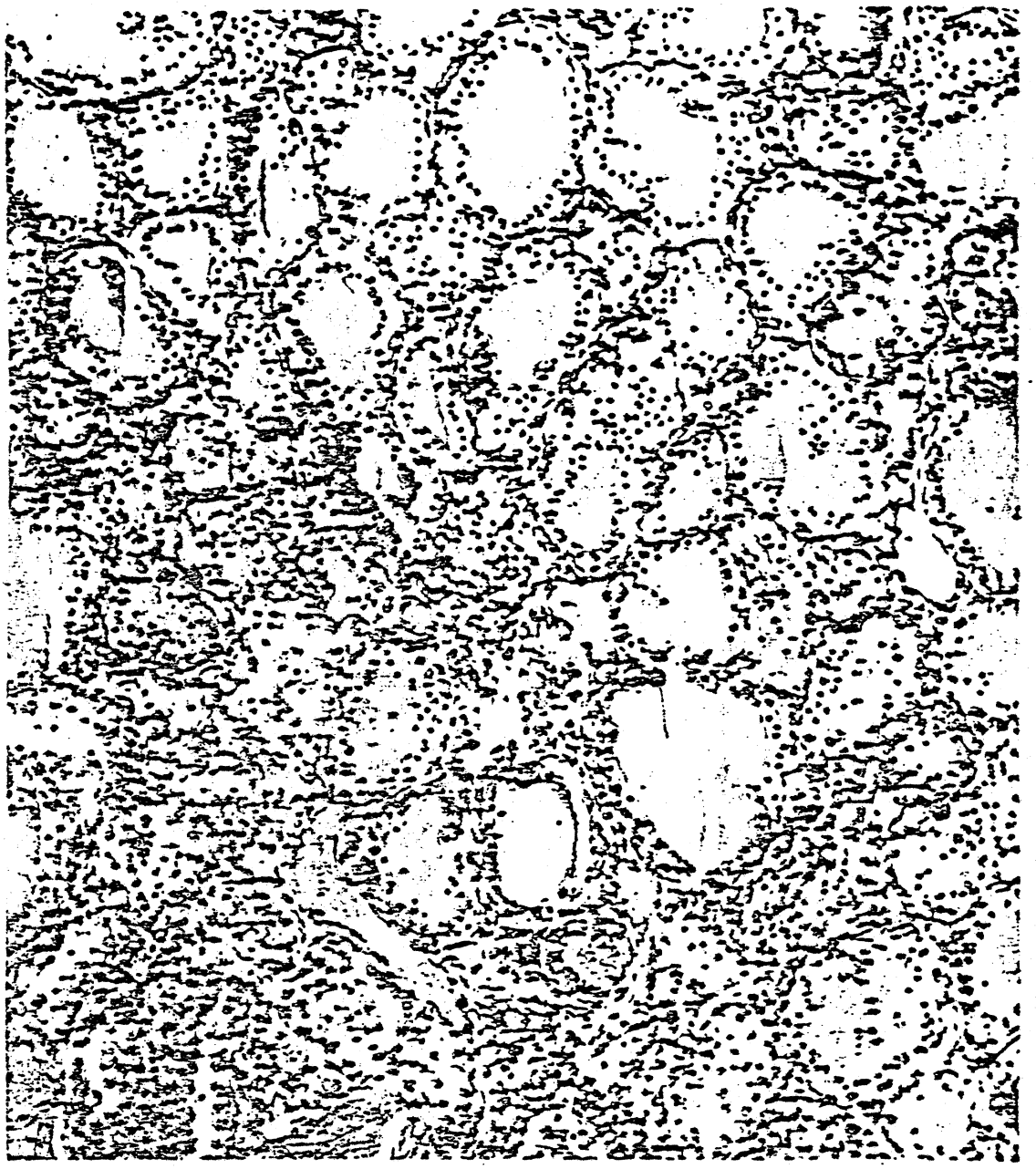

Figure 19. Thyroid Gland from experimental animal farm control sheep 34-326. Moderated postmortem Autolysis with Pyknosis of Nuclei. Compare with Figure 18.

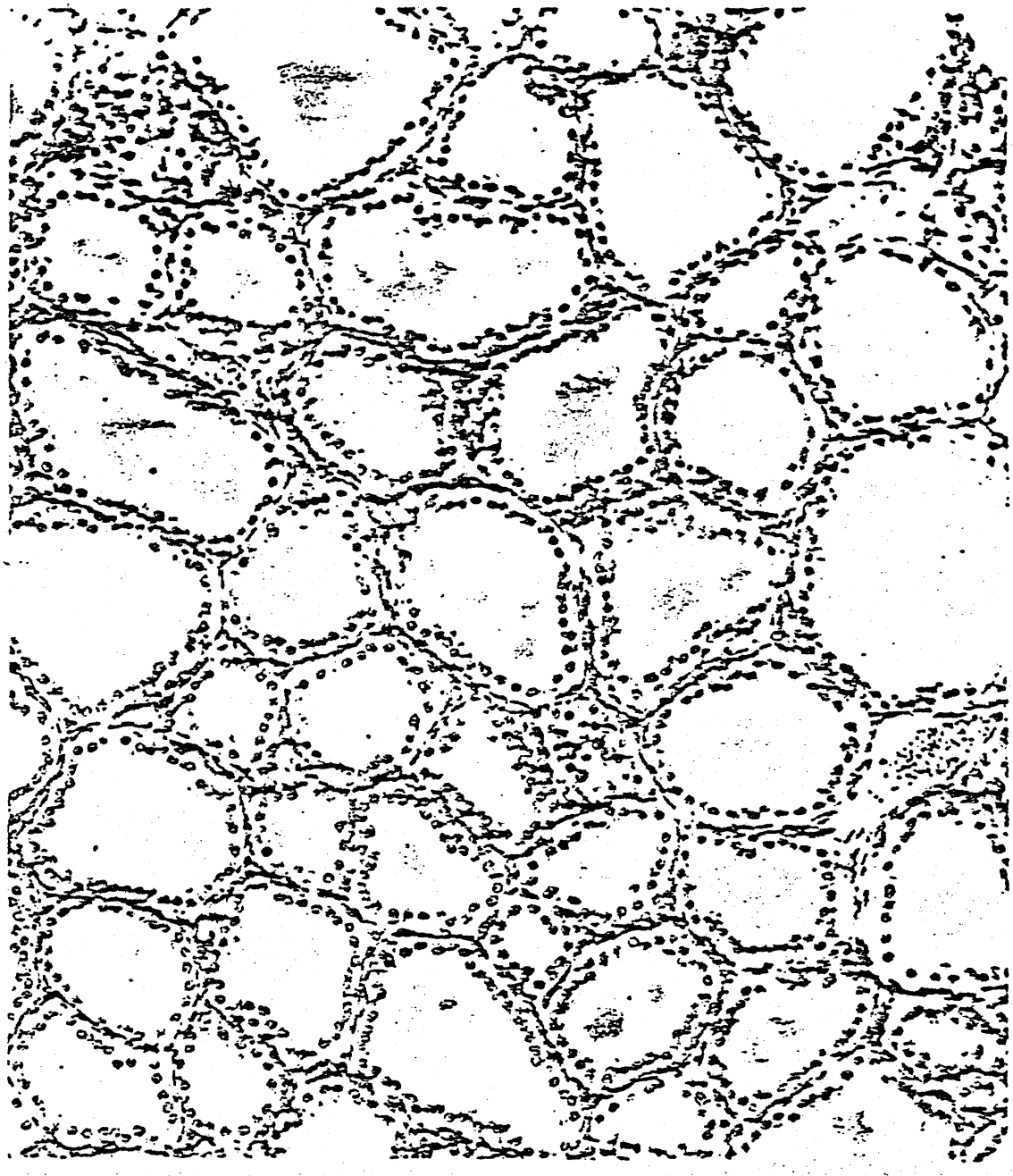

Figure 20. Thyroid Gland from Utah sheep #2. Follicles small with moderately high Epithelium and Peripheral Vacuolation of Colloid.

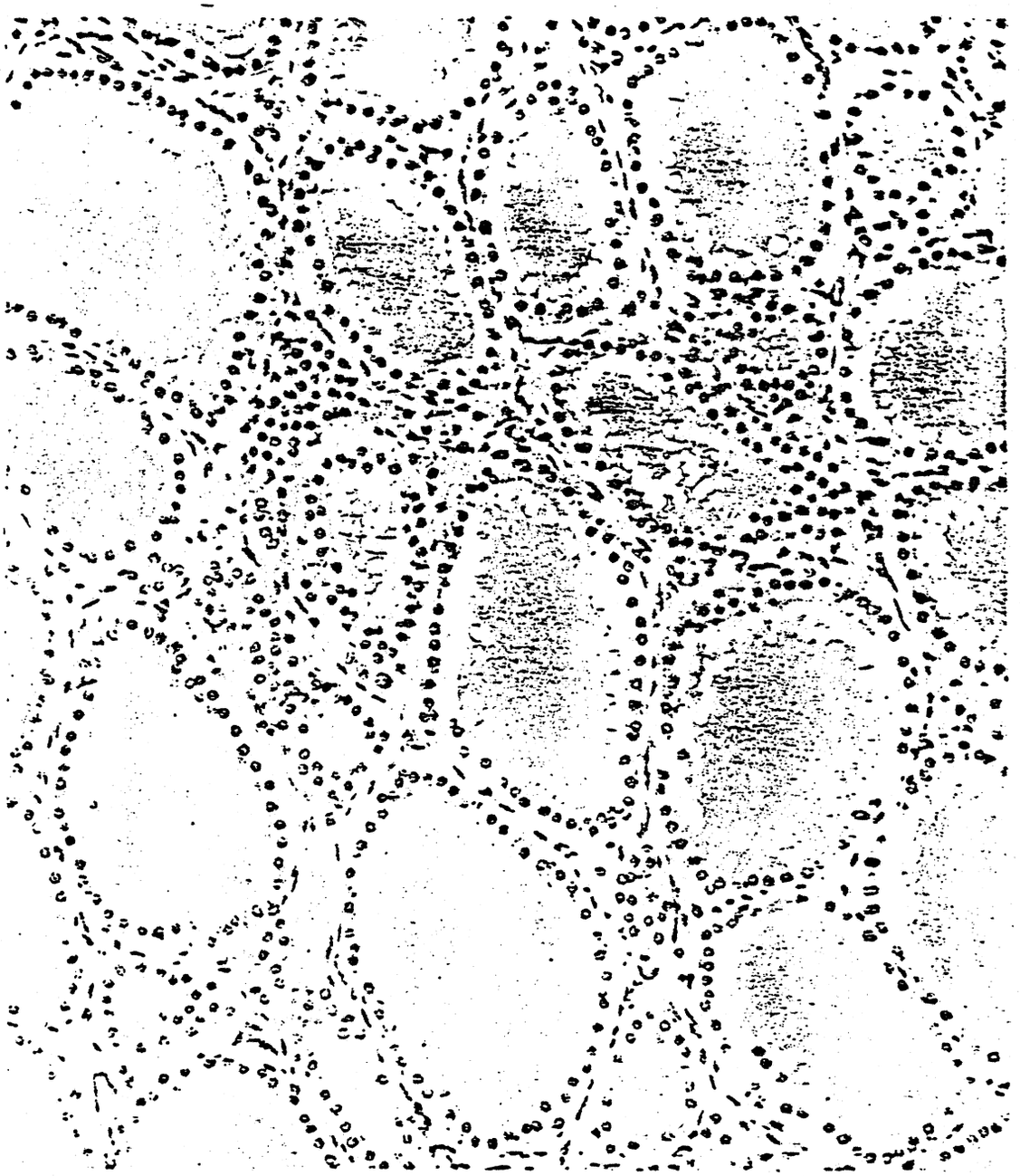

Figure 21. Thyroid Gland from experimental animal farm control sheep #37-006. Compare with Figure 20.

A.E.C. - G.E. - RICHLAND, WASH.

Figure 22. Thyroid Gland from Utah sheep #3 showing small Follicle pattern with high Epithelium.

A.E.C. - G.E. - RICHLAND, WASH.

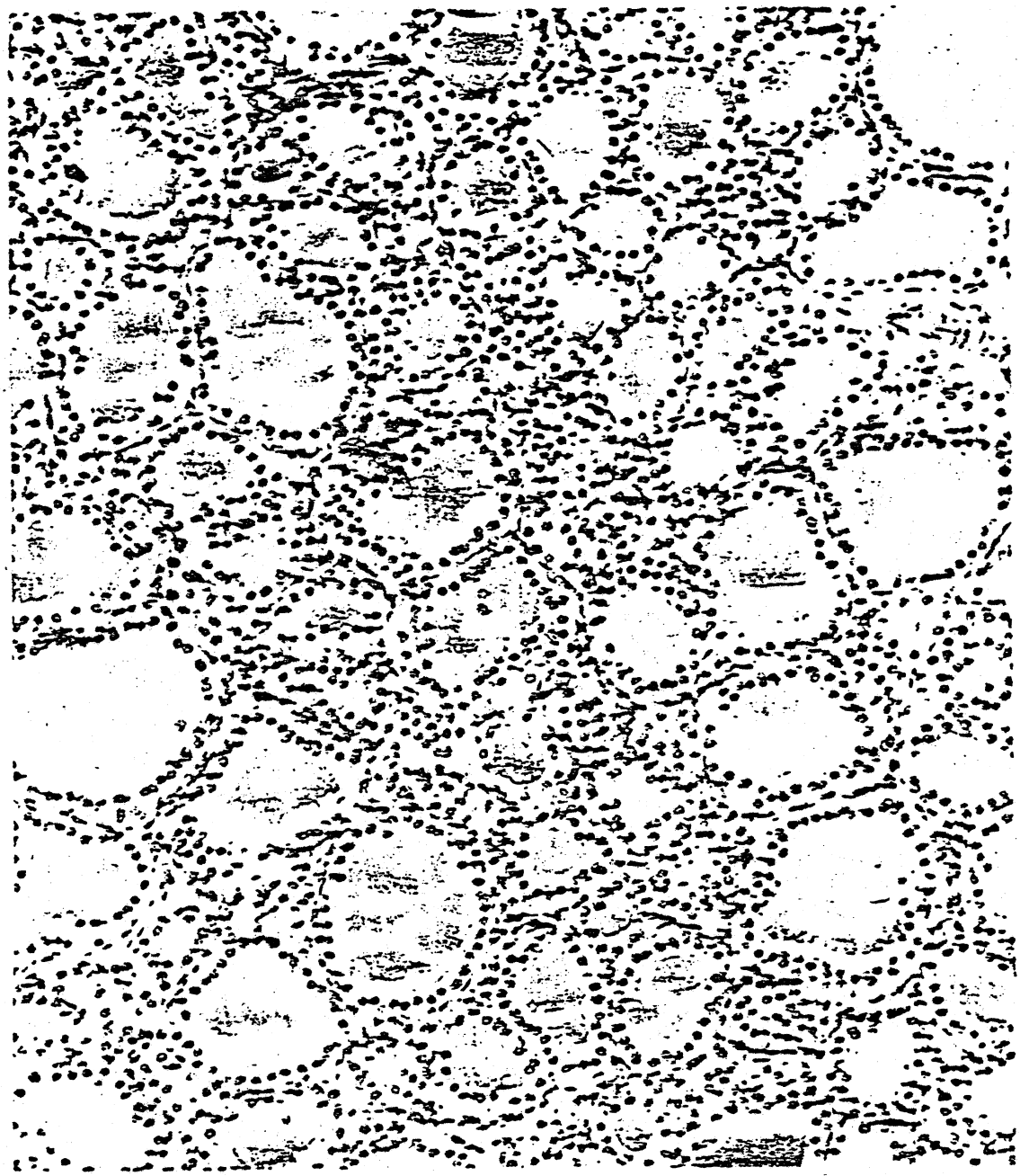

Figure 23. Thyroid Gland from experimental animal farm control sheep #24-19. Compare with Figure 22.

within the Utah sheep thyroid glands. The follicles were in intimate apposition to each other, the stroma having a normal delicate pattern. The variability in size of the follicles was compatible with the individual and age variation observed in control sheep at the Experimental Animal Farm.

The thyroid gland from animal #5 showed foci of mild perivascular inflammation in the areolar tissue external to the gland (Figure 24). The inflammatory cells were neutrophils and lymphocytes. Periglandular inflammation having an acute component was observed in exposed sheep at the Experimental Animal Farm only in the presence of definite tissue damage within the parenchyma. Moreover, mild chronic inflammation has been observed peripheral to the glands in control animals (Figure 25). In view of these observations on known exposed animals and their controls and the established decrease in radiation intensity in a radial direction from the central layers of thyroid tissue, inflammation external to the gland must be interpreted as nonspecific unless accompanied by evidence of radiation damage within the parenchyma.

Bone Marrow

The bone marrow sections submitted were of two predominant types. One type consisted of cellular marrow (Figure 26) while the other type represented predominantly fatty marrow with only small clusters of hemopoietic cells (Figure 27). Within the limitations of the tissue preparations it was felt that the cellular pattern was essentially normal in both types of marrow. Comparable bone marrow sections from Experimental Animal Farm control animals are illustrated in Figures 28 and 29. The sparse distribution of cells in the predominantly fatty marrow was interpreted as a feature of the location of the source of the tissue rather than a result of depletion of the cellular elements of the marrow.

Figure 24. Thyroid from Utah sheep #5. Focus of inflammation in tissue external to Thyroid Gland.

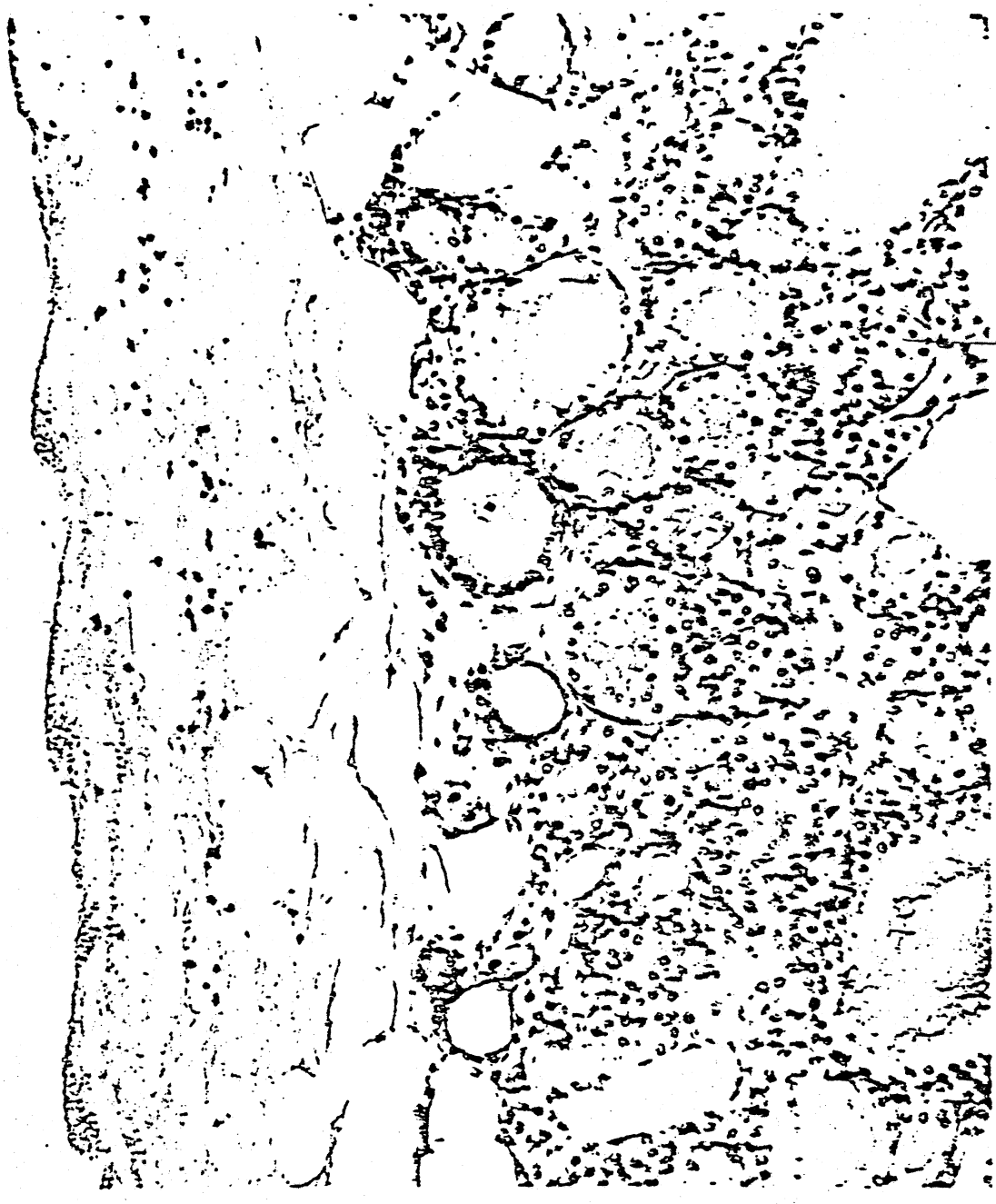

Figure 25. Thyroid Gland from experimental animal farm control sheep #37-034. Inflammation external to Parenchyma of gland. Compare with Figure 24.

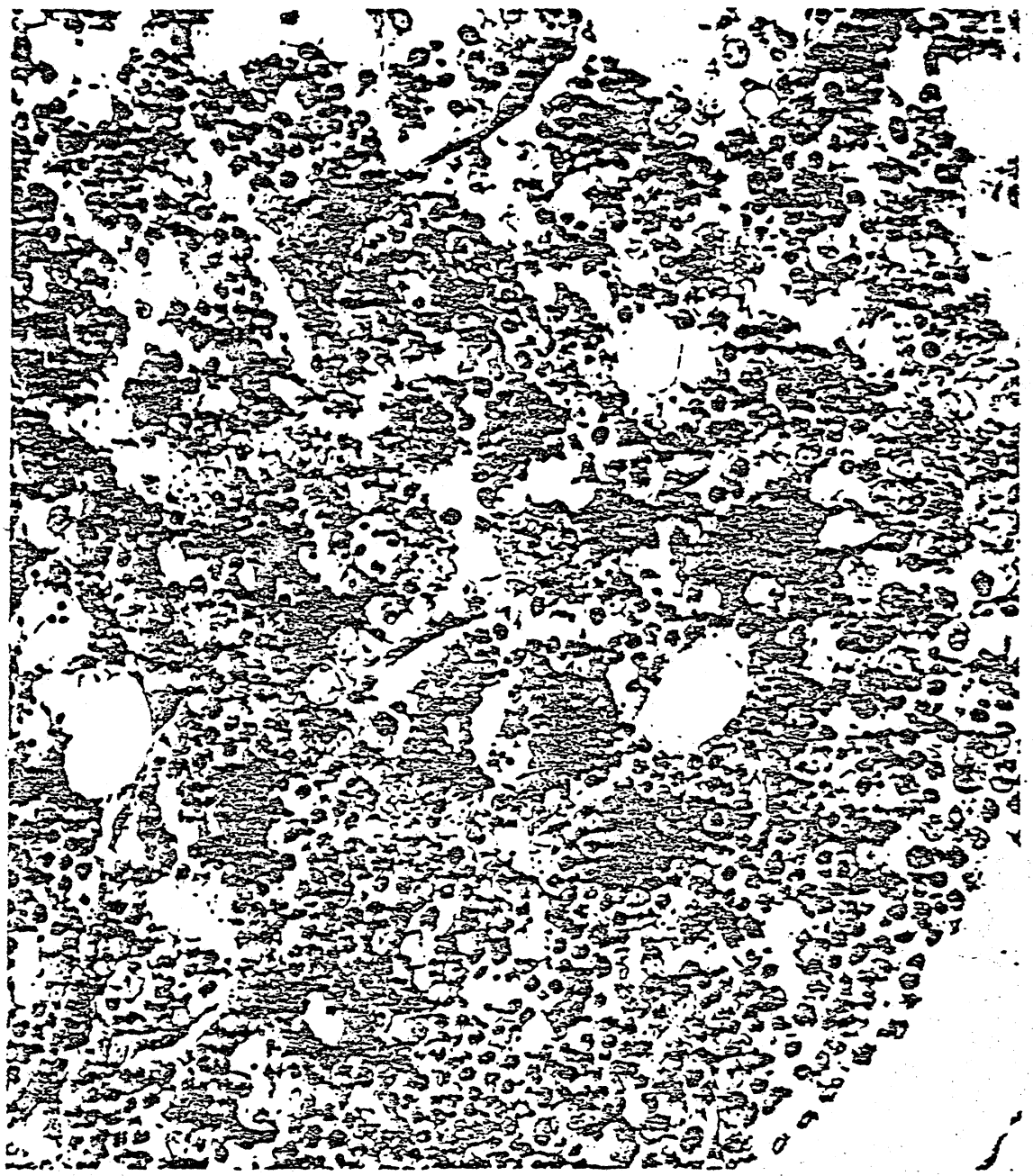

Figure 26. Cellular bone marrow from Utah sheep #5.

A.E.C. - G.E. - RICHLAND, WASH.

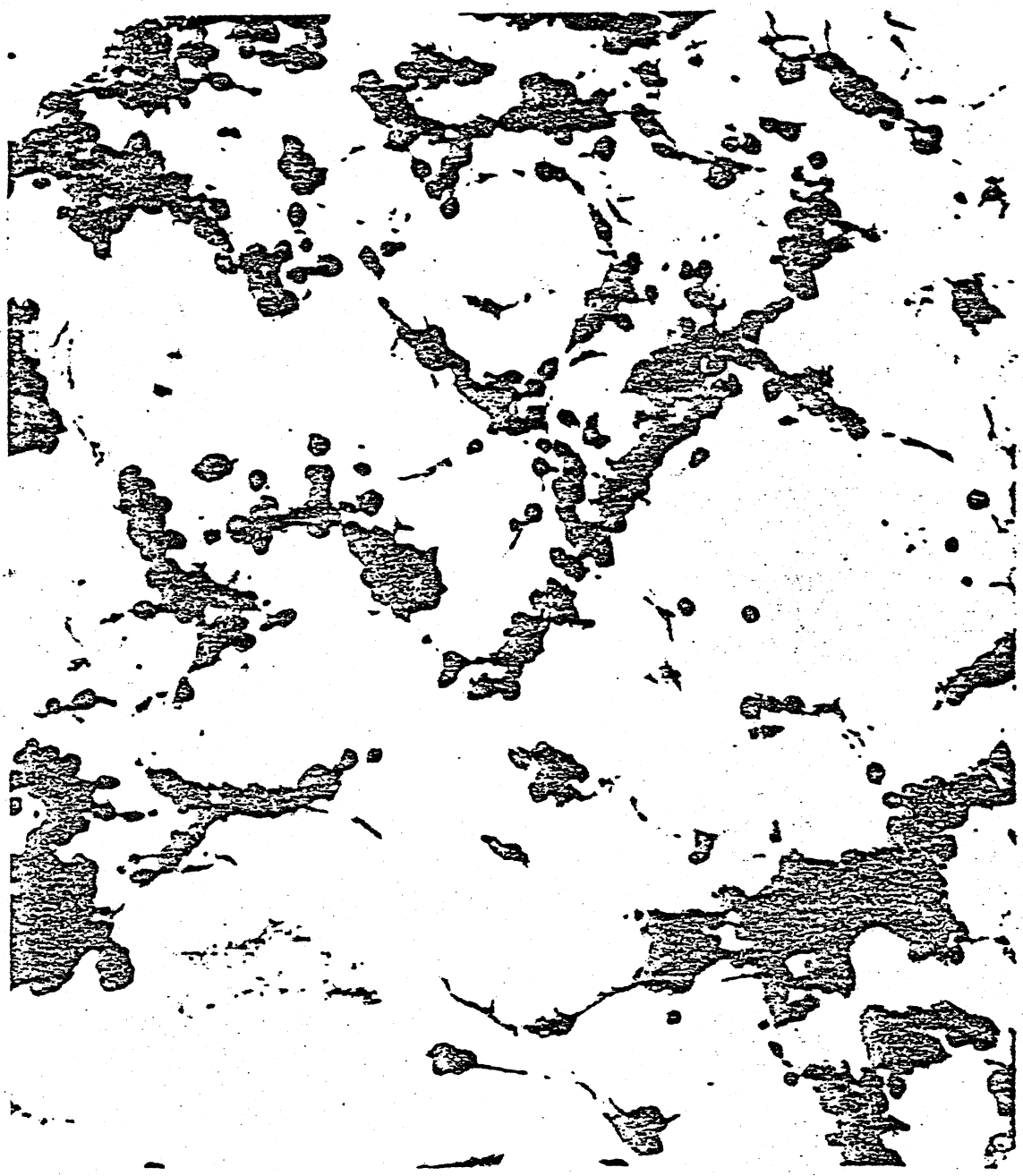

Figure 27. Predominantly fatty marrow from Utah sheep #2.

A.E.C. - G.E. - RICHLAND, WASH.

Figure 28. Cellular bone marrow from experimental animal farm control sheep #14-5. Compare with Figure 26.

AEC - GE. - RICHLAND, WASH.

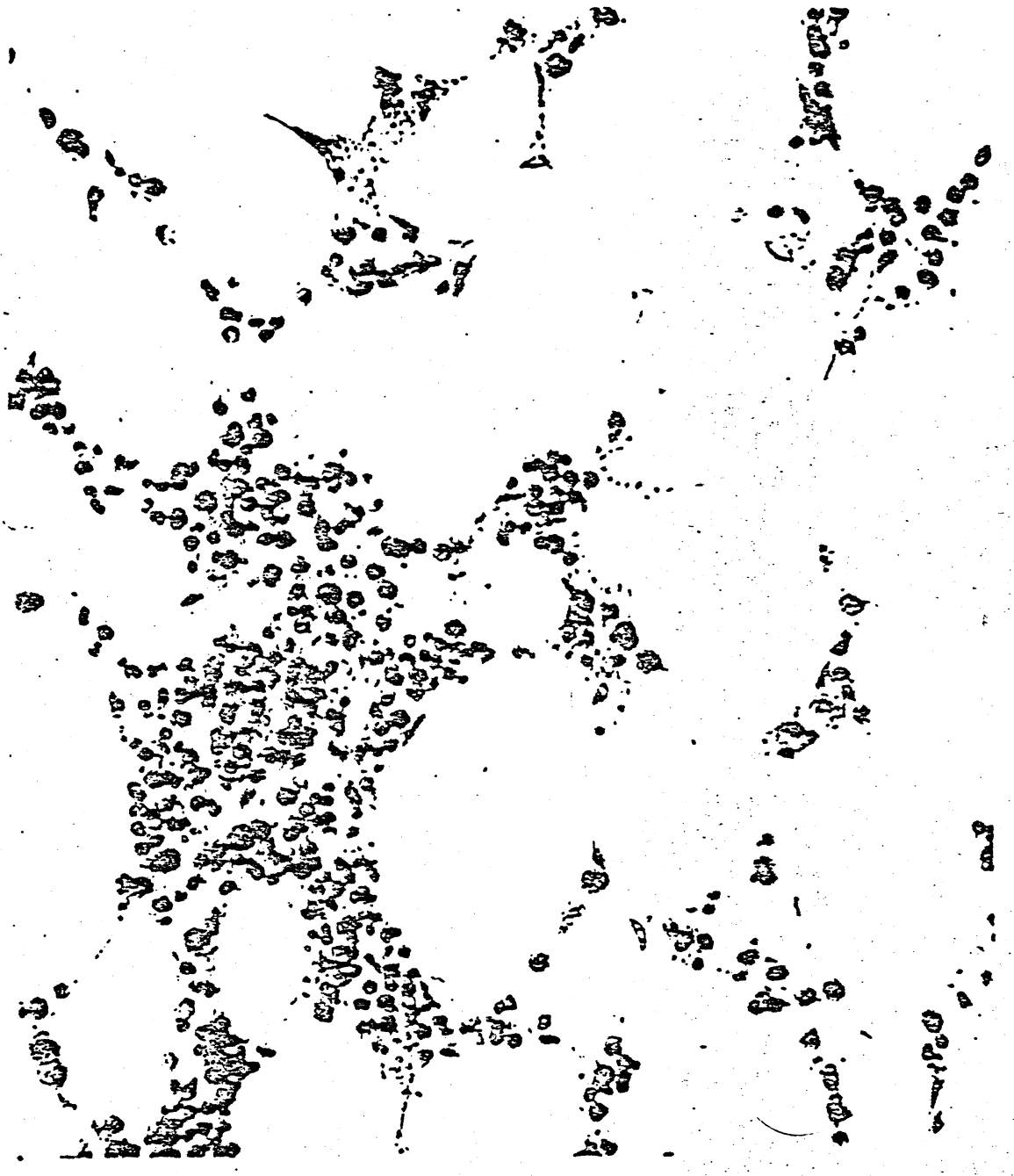

Figure 29. Predominantly fatty marrow from experimental animal farm control #48-119. Compare with Figure 27.

A.E.C. - G.E. - RICHLAND, WASH.

Other Organs

The other organs available in microscopic sections for this report included liver, spleen, kidney, adrenal gland and skeletal muscle. Among these organs only one tissue, the liver, showed pathologic effects. Fatty metamorphosis of variable degree was observed in some of the liver sections. This finding occurs in intoxications, systemic diseases, anemia or metabolic disturbances such as pregnancy disease or malnutrition. Fatty metamorphosis was observed at the Experimental Animal Farm in cases of prolonged chronic infection, inanition and pregnancy disease.

The results of the examination of skin specimens will be the subject of a separate report.

ESTIMATIONS RELATING VEGETATION CONTAMINATION TO THYROID DAMAGE

In previous sections of this paper it was demonstrated that the radiation dose required to cause minimal histological changes in the thyroids of young sheep in 18 days was 16,000 rep. Definite histological damage with evidence of progressive hypothyroidism will occur following a total dose of 50,000 rep delivered over a period of less than one month. It is of interest to estimate the initial concentrations of I^{131} and I^{133} in vegetation which would have to be ingested by grazing sheep to permit delivery of that amount of radiation.

The cumulative dose in rep received by a thyroid in m grams during a period of t_f exposure days is given by

$$D = \int_0^{t_f} \frac{55}{m} \left[Q_1 E_1 \pm Q_3 E_3 \right] dt \qquad (1)$$

where Q_1 and Q_3 = μc of I^{131} and I^{133} respectively in the thyroid, and

E_1 and E_3 = average energy in Mev of the beta particles from I^{131} and I^{133}.

Although the equation is based on the assumption that al- e energy of the beta particles is dissipated within the thyroid, this approximation is considered reasonable since losses due to the small size of the gland are compensated to some extend by neglecting the gamma dose.

Amounts of iodine in the thyroids will be functions of time, described as

$$\frac{dQ_1}{dt} = fq_1 - (\beta + \lambda_1)\ Q_1, \text{ and} \qquad (2)$$

$$\frac{dQ_3}{dt} = fq_3 - (\beta + \lambda_3)\ Q_3, \qquad (3)$$

where f = fraction of iodine ingested that deposits in the thyroid,

q_1 and q_3 = quantities in μc of I^{131} and I^{133} that are ingested, respectively

β = biological decay constant of iodine from the thyroid in $days^{-1}$, and

λ_1 and λ_3 = physical disintegration rate constants of I^{131} and I^{133} in $days^{-1}$.

Evidence that the assumptions inherent in the above expressions are reaonable was obtained from studies on the sheep at the Experimental Animal Farm. By means of large single tracer doses of I^{131}, the fraction f of the iodine fed which goes to the thyroid amounted to about 0.3, while the biological decay constant β was found to be $5 \times 10^{-2} \cdot days^{-1}$. For sheep fed a constant daily amount of I^{131}, equation (2) may be integrated and combined with equation (1) to give,

$$D = \frac{55 E_1 f\ q_1}{m(\beta - \lambda_1)} \left[t_f - \frac{1}{\beta + \lambda_1} \left(1 - e^{-(\beta + \lambda_1)t_f}\right) \right] \qquad (4)$$

Using the values listed above together with a weight of 8 grams for an average adult sheep thyroid, 0.09 day^{-1} for λ, and 0.2 Mev for E_1, cumulative doses were calculated for specific sheep using equation (4). Cumulative doses for these same sheep were calculated by a graphical integration of equation (1) from the experimentally measured values of the number of μc of I^{131} in the gland. The two values coincided to within a factor of two, a reasonable correlation considering

biological variation. (Since the parameters f, β, and m obviously would change as thyroid damage sets in, doses were compared only up to the time at which the thyroid ceased to function normally as indicated by the decrease in the radioiodine content of the gland.)

Using equations (2) and (3), it was of interest to determine the initial concentration of a fission mixture of I^{131} and I^{133} required on the vegetation ingested to deliver a given dose to a sheep's thyroid. Letting C_1 and C_3 represent these concentrations of I^{131} and I^{133} in μc per gram of forage and W the grams of dry forage which are consumed per day, the μc of I^{131} ingested per day following the initial ground contamination becomes $q_1 = WC\, e^{-\lambda_1 t}$. Incorporating this and a similar expression for I^{133} into equations (1-3), the total dose is

$$D = \frac{55fw}{m\beta}\left\{E_1C_1\left[\frac{1-e^{-\lambda_1 t_f}}{\lambda_1} - \frac{1-e^{-(\beta+\lambda_1)t_f}}{\beta+\lambda_1}\right] + E_3C_3\left[\frac{1-e^{-\lambda_3 t_f}}{\lambda_3} - \frac{1-e^{-(\beta+\lambda_3)t_f}}{\beta+\lambda_3}\right]\right\} \quad (5)$$

To find what the radioiodine activity density of forage must be initially to deliver a dose of 50,000 rep during time periods of 15, 30 and 60 days of grazing, the following data were used along with values already given:

$W \doteq 2 \times 10^3$ grams of dry forage/day

$E_3 = 0.5$ Mev

$\lambda_3 = 0.8$ days^{-1}

$C_3/C_1 = 7$ [approximate distribution of these radioisotopes in a fission mixture after 24 hours (8)]

TABLE 1

Initial Activity Density of Forage and Grazing Time Required to Cause Delivery of 50,000 rep to Thyroids

Days after ground contamination	Initial activity density of forage
15	1 μc I^{131}/g + 7 μc I^{133}/g
30	0.7 μc " + 5 " "
60	0.6 μc " + 4 " "

As can be seen from this table, the major portion, actually 90 per cent, of the dose to the sheep's thyroid from such a mixture of iodine isotopes is given within the first 30 days. Thus for n contaminations of the same magnitude each separated by a month or more, the value in the Table for 30 days may be simply divided by n to give the initial activity density of the vegetation ingested which would result in a dose of 50,000 rep.

CONCLUSIONS

1. The pathologic examination of tissues obtained from flocks adjacent to the Nevada Proving Grounds showed no evidence of significant abnormal findings in the thyroid gland, bone marrow or any organ other than the liver. The fatty metamorphosis in certain of the liver specimens is to be interpreted as resulting from a chronic wasting disease, malnutrition, or pregnancy disease.

2. Radioactive iodine, a fission product of key importance in the fall-out of atomic detonations and the wastes of plutonium production, must be administered in quantities in excess of 480 μc/day to adult sheep in order to produce an impairment of health in sheep within a period of five months, the clinical effect being invariably accompanied by severe histologic damage in the thyroid gland.

3. The emaciated condition of many Utah sheep was not observed in any adult animal receiving as much as 480 μc/day during a five-month experimental period. Chronic wasting disease was observed in a few ewes in the 240 μc group but only after 12 months of daily feeding of I^{131}.

4. Premature lambing described in some Utah sheep flocks was not observed in the experimental sheep at Hanford although some test animals were fed up to 1800 μc/day for 420 days.

5. The large number of deaths observed in adult Utah sheep was not observed in any acute or subacute Hanford experimental sheep fed up to 280,000 μc in a single dose. Deaths observed in experimental sheep did not occur until over five months following initiation of I^{131} feeding and was attributed to systemic disease complicating the chronic hypothyroid state.

6. Tissue sections from newborn Utah lambs were not available for comparison. However, no increase in deaths in newborn experimental animals was observed in any group in which there was absence of definite evidence of thyroid damage.

7. Although the skin studies will be the subject of a separate report, the skin lesions described in Utah sheep were not observed in experimental sheep. Although moderate wool loss was observed in a few animals, it did not appear until many months following loss of thyroid function. A rough wool coat and dry skin were more consistent findings. Extensive hair loss was observed in some off-project control animals following high fever associated with a systemic disease.

8. Estimates indicate ~~that an~~ average of 0.3 μc of I^{131} and 2 μc I^{133} (for two ground contamination events 60 days apart) to 1 μc of I^{131} and 7 μc of I^{133}/g of dry vegetation (for one ground contamination event) would be required to cause serious thyroid damage in 120 days and 15 days respectively.

ACKNOWLEDGEMENTS

The assistance of the following people is gratefully acknowledged:

1. Lt. Col. R. J. Veenstra, USNRDL and Lt. Col. J. H. Rust, UT-AEC, for supplying information and slides on Utah sheep,

2. L. A. George, Maj. C. A. Barnes, M. E. Kerr and staff of the Experimental Animal Farm,

3. Patricia L. Hackett and staff of the Clinical Laboratory, and

4. Jane Coleman of the Histology Laboratory.

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6. Marks, S., N. L. Dockum and L. K. Bustad, "Toxicity of I^{131} for Sheep. III. - Histopathology of the thyroid," Biology Research - Annual Report 1951, Document HW-25021, pp. 170-185 (1952) (RESTRICTED).

7. Marks, S., N. L. Dockum and L. K. Bustad, "Toxicity of I^{131} for Sheep. VI. Early histologic damage in the thyroid," Biology Research - Annual Report 1952, Document HW-28636, pp. 148-154 (1953) (UNCLASSIFIED).

8. Hunter, H. F. and N. E. Ballou, "Fission-product decay rates," Nucleonics 9, No. 2, c2 - c7 (1951).

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United States
Atomic Energy Commission
Washington 25, D.C.

BMB:PBP

December 11, 1953

Mr. James G. Terrill, Jr.
Acting Chief
Radiological Health Branch
Division of Engineering Services
Public Health Service
Department of Health Education & Welfare
Washington 25, D. C.

Dear Mr. Terrill:

I am sending you a copy of our draft report on the sheep losses in Utah. Attached is a report from Hanford on the Iodine Toxicity and the report from Los Alamos on the Beta Lesions.

The Los Alamos report is the original and we do not have a duplicate at this time, so we would like to have it returned at your earliest convenience.

I should be glad to have any comments or suggestions you have regarding the report. We would like to have a report which the Department of Health, Education and Welfare will concur in, and of course, a letter to this effect from you.

Sincerely yours,

(sgd) Paul B. Pearson
Paul B. Pearson
Chief, Biology Branch
Division of Biology and Medicine

Enclosures: Draft of Final Report on Sheep Losses Adjacent to the Nevada Proving Grounds
A Comparative Study of Hanford and Utah Range Sheep (Hanford Report - HW-30119) OUO
Comparative Study of Experimentally Produced Beta Lesions and Skin Lesions in Utah Range Sheep. (Los Alamos Report) OUO

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United States
Atomic Energy Commission
Washington 25, D.C.

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PUBLIC HEALTH ICE - BSS

Dr. Arthur Wolff and
Dr. Monroe A. Holmes

December 24, 1953

Asst. Chief, Radiological Health Branch

AIRMAIL

AEC Report on Sheep Losses Adjacent to the Nevada Proving Ground

Transmitted, herewith, is a copy of the above report. It will be appreciated if you will review and comment on the report.

AEC's intended purpose for the document is:

1. As an information paper for the members of the Commission.

2. As a source paper for a news release and for information to be given to the sheep men and the newspapers in the areas adjacent to Test Site.

We would appreciate receiving your comments, preferably by telephone, as soon as you can conveniently provide them, as Dr. Pearson, Chief, Biology Branch, Division of Biology and Medicine, AEC, would like to use this report shortly after the turn of the calendar year.

Samuel C. Ingraham, II, M.D.
Asst. Chief, Radiological Health Branch
Division of Engineering Resources

SCI:br

DEPARTMENT OF
HEALTH, EDUCATION AND WELFARE
~~FEDERAL SECURITY AGENCY~~
PUBLIC HEALTH SERVICE
WASHINGTON 25, D. C.

IN REPLYING, ADDRESS THE
PUBLIC HEALTH SERVICE

REFER TO: E2:25

December 24, 1953

Dr. George A. Spendlove
Director of Public Health
Utah State Department of Health
Salt Lake City 1, Utah

Through: A. Chief, Bureau of State Services

Dear Dr. Spendlove:

As discussed with you by telephone, transmitted herewith is a copy of the proposed Memorandum for Information from the Division of Biology and Medicine, Atomic Energy Commission to the Atomic Energy Commission about the Sheep Losses Adjacent to the Nevada Proving Ground. A copy of Dr. Pearson's letter of December 11th, forwarding the previous draft, is also enclosed.

Concurrent with your review of this draft-memorandum, the Bureau of State Services, Public Health Service, will be reviewing it.

Dr. Pearson plans to use the memorandum as an information paper for the members of the Atomic Energy Commission, as a source paper for an appropriate news release at the time related statements are made to the sheep men at Cedar City, tentatively during the week of January 11, 1954. This is, I believe, in accordance with the general procedure agreed upon last November.

I contacted Dr. Pearson to inquire about the sheep you mentioned during our conversation. He understands that one sheep shipped to Los Alamos during September or October was included in these reports. It is suggested that you check directly with Dr. Lushbaugh to be certain of this.

OFFICIAL USE ONLY

Dr. Pearson sent a copy of this report to Dr. Sims of the U. S. Department of Agriculture, and today informed me that that Department has expressed its concurrence with the report. Dr. Sims will probably get in touch with Dr. Melvin, Bureau of Animal Industry at Salt Lake City. Dr. Pearson has suggested that you may wish to get in touch with him also.

Because of the holidays, and because of Dr. Pearson's wish to meet with the sheep men before the middle of January, I will appreciate it if you can telephone either Dr. Ingraham or me prior to the new year, to discuss comments you may have concerning the report.

With personal regards.

Sincerely yours,

James G. Terrill, Jr.

James G. Terrill, Jr.
Acting Chief, Radiological Health Branch
Division of Engineering Resources

CC: Regional Director
HEW Region VIII

December 30, 1953

MEMORANDUM

FROM: Monroe A. Holmes,
Veterinary, Bureau States Services
Utah State Department of Health,
Salt Lake City, Utah

TO: George A. Spendlove, M.D.
Director of Public Health
Utah State Health Department

SUBJECT: Observations and Comments on Draft of Paul Pearson's Final Report on Sheep Losses, Dated December 16th, 1953.

Page 1 of Summary, Paragraph 3. This statement is too general. Although much of the evidence indicates radiation effects have not been found, there is still no conclusive evidence that will completely rule out radiation as a contributing factor.

Page 2, Paragraph 6, Line 1. Lesions on sheep were observed before shearing, although believe majority of lesions were observed after wool had been removed.

Page 3, Paragraph 9. Bone samples obtained from sheep of effected herds cannot logically and/or scientifically be assumed to be the same as if such samples were obtained from the sheep which had been actively affected, but had died. All specimens which were obtained from the sheep in the herds which had been affected, or at least from the herds which had losses, were sheep actually that had the least symptoms and lesions. Sheep which had shown pronounced symptoms with losses of lambs had died. Such sheep had been disposed of before investigating groups had done their studies.

Page 3, Last Sentence, Paragraph 9. This statement is fairly general especially in considering that range sheep are not necessarily comparable in resistance to well-fed and cared for experimental laboratory animals.

Page 4, Paragraph 12. There is no mention of the effects of radiation on gestation and pregnancy.

Page 5, First Line. Fatty changes in the liver were observed only in a few of the older cachectic ewes. These animals were not pregnant; therefore, pregnancy toxemia could not enter the picture.

Page 5, Paragraph 15. These animals were not emaciated, ere poor in condition comparable to a thin person with a fat person.

Page 5, Paragraph 16. There has not been sufficient suppo: evidence presented that these animals could not have been exposed to higher radiation, as the monitoring teams certainly did not cover the complete fall-out area. What coverage was done was along areas of easy access and not in the more rugged areas where the sheep were grazing, and where there were not adequate roads and easy access was not available.

Page 5, Paragraph 17. Radiation experiments completed should be considered presumptive; hence, although indicative of possible results, they did not parallel closely enough similar conditions which could have been induced on the open range.

Page 6, Paragraph 19. Although the induced experimental radiation of the sheep produced similar pathological affects on the skin similar to that observed in affected horses and cows, earlier conferring sessions produced evidence which was recorded that such effects were not observed in sheep.

(Although the statement seems ambiguous it is due to the apparent confusing presentation of facts, so that conclusions could not be drawn by observers who were not sufficiently trained in the pathological radiation results.)

Page 6, Paragraph 20, Second Sentence. It is stated that specimens had been obtained from affected sheep. It is not known whether or not this particular sheep was similarly affected. It was the only one of several thousand observed that had any evidence of skin lesions. Such lesions may have been caused by trauma.

Page 7, Paragraph 21. Of the listed conditions not one chance of the word histologically, biologically, pathologically resembling that phase, form, manner, or condition of lesions which were observed in the Cedar City sheep. The lesions observed in the Cedar City sheep have not in the knowledge of five veterinarians and many old-time sheepmen of thirty to fifty years experience, had ever occurred within the same manner and with the same results as listed or mentioned in this paragraph. This is too broad, too general, and too inclusive a statement.

In the body of the report there has been no mention concerning the reason for the stunted lambs and their deaths, and deaths of ewes during birth or shortly thereafter. The main concern of the report seems to be largely on the external body lesions and not necessarily the over-all clinical and pathological picture. No reference has been made of the lack of general pathological condition, although this again may be contributed to the fact that the sheep which were examined were possibly those which had been the least affected.

UNITED STATES
ATOMIC ENERGY COMMISSION
WASHINGTON 25, D. C.

IN REPLY REFER TO:

EMB:PBP

January 5, 1954

Dr. George Spendlove
State Department of Health
Capitol Building
Salt Lake City, Utah

Dear Dr. Spendlove:

I am sending you a copy of the report that has been prepared for the sheepmen, together with reports from Hanford on iodine toxicity and the Los Alamos Scientific Laboratory on beta burns.

Information contained in these reports should not be made public or released to the press prior to our meeting in Cedar City.

Sincerely yours,

Paul B. Pearson

Paul B. Pearson
Chief, Biology Branch
Division of Biology and Medicine

Enclosures: 3 Reports

AIR MAIL

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AIR MAIL

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