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Bioclimatological Studies on White Rats in South Africa. No. 1.—Skin Cancer in Rats following continued exposure to sunlight.

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As a small mammal with an unpigmented skin and lacking in sweat glands, the white rat (Wistar strain) can be considered as a particularly suitable test animal for studying comparative biological effects of sunlight and shade over prolonged periods. Apart from its academic interest, bioclimatological work of this nature is of very real practical significance especially in a country such as South Africa with its clear skies and abundant sunlight to which the vast majority of the human and animal population is continuously exposed throughout life. In order, therefore, to gain further detailed information on this matter, an experiment was started at Onderstepoort in October, 1941, with batches of young white rats which were drafted into the investigation in relays over several seasons.

Whereas the general outcome of these findings will be published elsewhere, this paper is devoted exclusively to an account of the specific skin lesions in those rats exposed to sunlight.

In regard to the planning of this work the following brief description provides the essential details.

Three main groups of young male rats, approximately four weeks old were drafted into experiment immediately after weaning, the body weight of the whole series varying between 40 to 50 grams at the start. Each group was comprised of 10 animals placed in two standard-sized wire cages with five rats to each cage. All animals were fed throughout on a well-balanced dry ration of standard quality. Both the feeding and the watering were arranged so as to allow for accurate weekly determination of the intake by the various groups. Likewise the body weight of all individuals was recorded weekly. While one half of the animals in each group was allowed to consume unrestricted amount of food, the ration of the other half was carefully restricted so as to allow for minimal growth only.

Experiment I (See Tables I and II).

Animals were divided into group A1 (5 animals) on restricted diet, and group A2 (5 animals) on full diet. All these animals were regularly exposed to sunlight (i.e. on clear days) for a period of 4½ *hours* daily, starting at sunrise. After full exposure to the sun during the forenoon the cages were then placed under a hessian shelter thereby allowing sky radiation only on

to the animals for the rest of the day. Previous short term investigations had shown that rats exposed to sunlight after midday succumbed as the result of heat stroke during hot weather.

Experiment II (See Table III).

Animals were divided into group B1 on restricted diet, and group B2 on full diet. All animals in this group were exposed daily for $2\frac{1}{2}$ *hours* only to sunlight starting at sunrise. For the rest the treatment was similar to that described for groups A1 and A2.

Experiment III (See Table III).

Animals were divided into group C1 restricted diet, and group C2 full diet. All animals in this group were *continuously sheltered* in a stable away from doors and windows, in an area constantly provided with a subdued diffuse daylight, i.e. completely out of reach of any sunlight.

Experiment IV.

A further experiment was commenced on 1.4.42 on similar lines as experiments I, II and III, and was comprised of similar groups.

Of 22 rats (see Table I) exposed for $4\frac{1}{2}$ *hours* daily to sunlight, 13 developed skin tumours which in the majority of cases affected the ears. Of the 22 rats exposed for $2\frac{1}{2}$ *hours* daily, only one rat (No. 60) developed neoplasms on both ears. The earliest development of a new growth was seen in rat No. 54, in the form of a nodule on the upper eyelid, and which appeared approximately 10 months after exposure. Earlier changes in the skin of the ears of this rat may not have been observed . The left lower eyelid was affected in 4 rats, the left upper eyelid in 2, the right lower eyelid in 8, the nose in 3, the left foot in 1, and the right foot in 1 rat. In 3 rats the noses were involved, and in one both front feet. One rat developed a swelling in the left ventral aspect of the neck, attached to the angle of the jaw, under the skin. It is not clear whether this was of the nature of a metastasis or an infiltration. New growths were detected only on those parts of the skin not covered by hair and which were freely exposed to sunlight. The skin of the tail, however, was in no case involved probably as a result of the degree of protective keratinisation normally present. In the majority of rats new growths appeared on more than one locality of the skin. Of the total number of rats exposed for $4\frac{1}{2}$ hours daily, 6 out of 11 on a *restricted* diet developed skin tumours while 8 out of 11 on a full ration were likewise affected. Although both groups were definitely susceptible there was some evidence to suggest that tumour development was slower in the groups kept on a restricted diet than amongst the others.

The first changes observed appeared as a roughening or thickening of the skin, i.e. a form of hyperkeratosis which subsequently became transformed into a new growth which was either wart-like or of the nature of an indurated nodule and frequently light reddish in colour. Some of these were no larger than a pin's head. It was most remarkable how quickly these neoplasms increased in size after they had made their appearance. In some instances the whole ear (Rat A1/58) became involved in a large growth, with an ulcerating bleeding surface. In the case of the nose (Rat A1/46), the growth caused so much disfiguration, that it was difficult to locate the external nares. In one rat the eye was completely closed by a neoplasm which had developed on the right lower eyelid. It was raised above the

surface to an extent of about 1 cm., with infiltration into the surrounding tissues (Rat A1/38). In the majority of these large growths there was ulceration, and haemorrhage from the surface and in some cases necrosis and/or inflammatory changes extended into the mass of the new growth. On section these neoplasms were greyish white and marrowlike in consistence, and on pressure pitted easily. Some of the rats, (especially in Experiment IV, which were not killed or which did not die as a sequel to the neoplasms, developed a characteristic lung complication. This also occurred amongst the rats kept in the shade, and was of the nature of a focal muco-catarrhal pneumonia (Quin, 1945). They lost weight rapidly, while gurgling sounds became audible over the thorax. This condition is apparently well known in America and is said to be due probably to a genetically transmitted lethal factor. It should be stressed that one rat (Rat B026), exposed for $2\frac{1}{2}$ *hours daily* from 7.10.41 revealed wartlike growths on both ears on 18.5.43 and microscopically these were diagnosed as an epidermoid carcinoma.

Microscopic Picture.

The earliest changes seen microscopically were of the nature of epithelial pearls, concentrically laminated with epidermoid cells on the outside, and partially or fully keratinized cells on the inside. In some instances this was associated with hyperkeratosis. The nuclei of these cells varied greatly, only multi-nucleated cells were commonly seen. In many of the sections studied, the cells showed marked anaplasia, varying in shape and size, from spindle-shaped cells arranged in whorls to those polyhedral in character, especially in the depth of the new growth. Giant cells with giant nuclei were not uncommon in such situations. The nuclei also varied in size, shape and number, some containing more than one nucleus and many showing irregular mitosis. Some nuclei were round, some spindle-shaped, and others polyhedral.

In places the cells and their arrangement resembled spindlecell sarcomata. In every case examined the neoplasm was of the nature of an epidermoid carcinoma (Acanthoma, or Squamous cell carcinoma). Some of them passed through the preliminary papillomatous stage as described by Ewing (1928), *whereas others were flat, depressed, indurated, and infiltrating from an early period onward. In the more advanced stages in both types there was erosion and ulceration.*

Putschar and Holtz (1930) believe they were the first to show that skin cancer in rats can be regularly produced by the effect of ultraviolet rays (Quartz Lamp). The rats used in their investigations showed no evidence of *spontaneous* skin neoplasms and amongst 1,000 rats one animal died of a peritoneal sarcoma (see reference to Rat B1/60). They also refer to a variable picture, such as swollen ears with enlarged edges, eyelids thickened thus obscuring the conjunctiva, and eyeball opacities. Several changes were encountered in the same animal, affecting the nose, ears, feet, etc., resulting thereby in a grotesque appearance. There is no doubt that these naked eye characters referred to by them closely resembled the picture seen in the Onderstepoort rats. They also mention the polymorphous nature of the cells, and arrived at a diagnosis of an undifferentiated sarcoma-like growing carcinoma. They identified metastasis only in 3 animals, in areas situated subcutaneously and regionally near to the eye. It is not known whether the metastasis was into lymph glands, because these tissues were not identified.

Several other authors refer to the production of skin neoplasms in rats following exposure to ultraviolet light. Findlay (1929) refers to rapidly

growing papillomata, and Wahlgren (1932) mentions two main types of neoplasms observed in mice: (*a*) a more or less Cornifying Squamous-cell carcinoma, and (*b*) an undifferentiated Sarcoma-like tumour built up of polymorphous, often fusiform cells. From this it seemed probable that even this sarcoma-like type was of an epithelial nature. Martin and Stewart (1935) state that the epithelial origin of this spindle-cell epidermoid carcinoma had been well recognised in the European literature. Rusch and Baumann (1939) refer to the wide variation of the cells, not only in different neoplasms, but even in different parts of the same growth. Although epithelial in origin some resemble sarcomata. Some were invasive, and an occasional metastasis was observed in the neck. No secondary growths were found in the viscera. The extreme anaplasia of these growths are referred to by Brookes (1943). He describes typical squamous carcinoma cells with a slight amount of keratinisation amongst the deeper layers of fusiform cells.

Roffo (1935) was able to cause malignant neoplasms in rats and mice by exposure to the sun. Up to then such neoplasms had only been experimentally brought about by ultraviolet light. Six hundred rats were thus exposed for about 5 hours daily. These rodents being very susceptible to heat were not exposed between 11 a.m. and 1 p.m. After 3 months he observed hyperkeratosis, brown patches, and dilatation of the blood vessels. Malignancy commenced after 7 to 8 months. Neoplasms occurred in the hairless parts of the body, mostly on the ears, followed by eyelids, nose, tail, and digits of the front feet. In some situations carcinomata occurred, while in others spindle-cell sarcomata were described. Thus it is stated that in the same animal carcinoma occurred on the ear, and sarcoma on the eyelids. The general concensus of opinion, however, is that the growths described by Roffo were not sarcomata, but spindle-cell-like epidermoid carcinomata.

Roffo also refers to a hypercholesterinaemia in the non-protected parts of the body, which sets in after a few days' exposure. He considers this important, because cholesterin is a nutritive photoactive and heliotropic substance. Baumann and Rusch (1939) maintain that their experiments do not support the theory that cholesterol is a primary factor in the production of neoplasms in the albino mice. Although the neoplasms were readily produced by irradiation, the cholesterol content of the skin, and of the ears was not increased, and mice on 2 per cent. cholesterol in their diet developed neoplasms at exactly the same rate as those on the stock diet. The cholesterol content of the skin was increased by irradiation in the rat, but *not* in the mouse.

These experiments on mice by Roffo of Buenos Aires caused so much publicity that the Academy of Medicine in Paris appointed a committee to verify these observations. Seeing that rats and mice displayed such sensitivity to ultraviolet rays, the committee concluded by directing the attention of individuals who abuse sun baths to the potential danger of such exposures.

Beard, Boggess and von Haam (1936), however, did not share the far-reaching conclusions of the Academy of Medicine of Paris, that sunlight and sunbaths may have dangerous carcinogenic possibilities for the human race. Since the normal habitat of the rat is darkness, and one year in the life of the rat is comparable to 30 years in man, seven months continuous radiation required in the rat to produce neoplasms, would be equivalent to 20 hours daily ultraviolet irradiation for about 18 years in man. This illustrates the

necessity of careful consideration in interpreting the results obtained experimentally in laboratory animals and then applying these to man.

Summary.

1. Skin cancer in rats (and in mice) can be produced by exposing them daily for definite periods to *ultraviolet light*.

2. Roffo produced identical neoplasms in rats by exposing them daily for 5 hours to *sunlight*. This was confirmed in the experiments at Onderstepoort, where rats were daily exposed for 4½ hours to sunlight. In one instance a new growth developed in a rat exposed daily for only 2½ hours.

3. So far no spontaneous skin cancer have been observed in the rats at Onderstepoort when kept under sheltered conditions but in one rat in these experiments, a fibroblastic sarcoma was found in the liver, lung, and omentum.

4. The skin cancers occurred on the hairless parts of the skin, and in the majority of rats new growths appeared in more than one place on the body. The ears were most frequently affected.

5. There was no definite occurrence of metastasis into other organs.

6. The earliest appearance of a new growth, to which attention is drawn, was + 10 months after exposure of the rats to sunlight.

7. In all the new growths a microscopical diagnosis of an epidermoid carcinoma was made. The statement by Roffo that some of these neoplasms were of the nature of sarcomata could not be confirmed at Onderstepoort.

8. The earlier lesions revealed the usual characteristics of an acanthoma associated in some cases with hyperkeratosis, while in the large actively growing neoplasms there was much evidence of anaplasia.

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APPENDIX I.

In this report a description will be given only of the development of skin tumours as noted in the individual animals.

GROUP A1 (ON RESTRICTED DIET) EXPOSED TO SUNLIGHT FOR 4½ HOURS DAILY.

On 29/11/41.—One rat (No. 51) died from heat stroke following exposure on a very hot day.

On 31/1/42.—Another one rat (No. 65) died from heat stroke. Consequently this group was left with three animals only for the rest of the experimental period.

12*th August*, 1942.

RAT *No.* 54.—Left eye, top lid small, round, bright red swelling, size of small round shot (photographed), removed completely for microscopic examination. Right eye, top lid, also slightly roughened.

No. 33.—Left eye, lower lid, large, round, red swelling size of pea and covered with red scab, eye somewhat watery. Right eye—nothing definite.

No. 58.—Right eye cornea opaque, no tumour formation.

4*th September*, 1942.

No. 33.—Left eye, lower lid, round tumour, about size of pea, smooth, pinkish red, except outer surface which shows thick greyish scab. Whitish secretion from the eye, which is partly closed. Right eye, lower lid, very slightly roughened, just visible. Right ear shows a small, round, hard, button-like thickening, light grey in colour.

No. 58.—Opacity cornea right eye, very distinct. Left eye, lower lid slight roughening. Slight opacity cornea. Both ears show thickening, slight wartlike growth somewhat sunken.

No. 54.—Right eye, upper lid, small but distinct roughening due to proliferation of epithelium. Left eye, slight opacity cornea. Eyes small. Slight thickening both ears.

28*th September*, 1942.

No. 54.—Left eye normal. Right eye, top lid, small papilla, on kind corner.

No. 58.—Right eye opaque, middle of top lid diffusely red papilla, size of small pin's head. Left eye small, opaque, otherwise normal. Left ear thickened, showing horny outgrowth. Right ear also slightly thickened.

No. 33.—Left eye lower lid, tumour slightly enlarged, only top covered with scab, bleeding. Slight whitish secretion from eye. Right eye apparently normal.

9*th October*, 1942.

No. 33.—Left eye, lower lid, tumour approximately the same size, no tendency to enlarge. Outer surface raw, bleeding somewhat through scratching. Right eye nothing definite. Right ear, button-like thickening, hardening, slightly purplish on inside. Left ear slight thickening.

No. 58.—Eyes opaque and small. Right eye, upper lid rounded, thickening, size of pin's head, bright pink. Left ear, marked thickening, horny outgrowth, bright pink.

No. 54.—Eyes small, somewhat watery. Left eyelid nothing definite. Right eye, small papilla, slight thickening.

15*th November*, 1942.

No. 33.—Tumour on left eye showing marked enlargement with tendency to bleed.

No. 58.—Thickening both ears, with hornlike outgrowths from inner surface. Frequently scratched with tendency to bleed.

No. 54.—Diffuse round swelling middle toe of right foot, size of small pea, bright red. Also small diffuse thickening on right side of nose.

21*st December*, 1942.

No. 33.—Enlarged tumour left eye, completely closing the eye. Definite tendency to bleed. Subcutaneous swelling on left ventral side of neck.

No. 54.—Tumour on right foot markedly enlarged involving whole foot which is partly eroded away through constant licking by animal. Diffuse enlargement on right side of nose.

No. 58.—Both ears diffusely enlarged and thickened on to side of head. Tumours very vascular especially round base, covered with red scabs following repeated bleeding.

All three of the above animals were killed on 21/12/42 for autopsy and collection of specimens.

Simultaneously rat *No.* 66 *from Group B*1 (2½ hours sunlight daily) and rat *No.* 64 *from Group C*1 (fully sheltered from sunlight were also killed for autopsy.

Compared with the rats from Groups B1 and C1 all three the animals from Group A1 appeared anaemic although the average body weight of animals from all three the above groups was very similar.

GROUP A2 (ON FULL DIET) EXPOSED TO SUNLIGHT FOR 4½ HOURS DAILY.

On 30/1/42 one rat No. 63 died from heat stoke on a very hot day leaving four rats in this group for the rest of the experimental period.

12*th August*, 1942.

No. 38.—Photographed. Right eye very large, diffuse, purple red swelling of lower eye lid extending on to side of face. No scab or bleeding surface. Left eye, lower lid slightly but definitely roughened.

No. 56.—Left eye, lower lid slightly roughened.

No. 46.—Right eye, top lid slightly roughened. Left eye, lower lid also roughened.

No. 51.—Left eye. lower lid small round, pinkish swelling, size of pin head. Right eye nothing definite.

4*th September*, 1942.

No. 38.—Tumour right eye markedly enlarged, about ¾ inch in diameter. Prominently bulging. Raw bleeding surface on top. Blood vessels round about base prominently visible. No sign of spread to neighbouring parts. Left eye, lower lid slight roughening but pale and uninflamed. General condition of rat quite good. Animal lively.

No. 46.—Left eye, lower lid very slight roughening. Right eye, lower lid very slight roughening. Ears both slightly thickened. Eyes small.

No. 56.—Ears slightly thickened. Right eye normal. Left eye lower lid very slightly roughened.

No. 51.—Left eye, lower lid small, but definite roughening, size of small pin head. Ears slightly thickened.

14*th September*, 1942.

No. 38.—Killed for autopsy and collection of material. Tumour right eye markedly enlarged and bleeding.

28*th September*, 1942.

No. 51.—Left eye, lower lid papilla hind corner, increasing. Tumour, size of pin's head, reddish. Two small papillae in front, also increasing. Right eye, hind corner, both lids diffusely thickened. Very red and vascular. Definitely increasing in extent.

No. 46.—Left eye lower lid very small reddish papilla. Right eye, top lid middle section small papilla, showing outgrowth. Both eyes slightly watery.

No. 56.—Left eye nothing definite. Right eye nothing definite. Slightly watery.

9*th October*, 1942.

No. 46.—Left eye, lower lid slightly diffuse roughening, pinkish red. Right eye nothing definite.

No. 56.—Left eye, slight thickening above top eyelid, slightly pinkish. Right eye nothing definite. Ears normal.

No. 51.—Left eye, lower lid papilla more enlarged, size of pin's head. Right eye diffusely thickened, mainly on posterior part of top lid.

15*th November*, 1942.

No. 51.—Tumour left eye diffusely enlarged with repeated bleeding. Found dead in cage on morning of 16th November with tumour eaten out by other rats. Carcass very anaemic probably through excessive bleeding from eye tumour. No material was collected for examination.

21*st December*, 1942.

No. 56.—Left eye completely closed by large, protruding dark red tumour covered by dry scab.

No. 46.—Left eye, lower lid shows small roughened tumour size of split pea.

Table I.

Albino Rats exposed for 4½ hours to Sunlight from 7.10.41.

Group.	No. of Rat.	Naked-eye Characters.						Specimen No.	Diagnosis.
		12/8/42.	4/9/42.	28/9/42.	9/10/42.	15/11/42.	21/12/42.		
A1, Males, exposed for 4½ hours daily from sunrise (on restricted diet)	54	*Left upper eyelid* bright red round nodule excised)	—	—	—	—	—	28180 (excised nodule)	Epidermoid carcinoma (early lesions)
		Right upper eyelid roughened	*Eyelid* distinctly roughened	Small nodule on eyelid	—	—	*Both ears* show nodules	28632 Killed for P.M. 21/12/42	—
		—	—	—	—	—	New growth covers the whole of the right *foot*	,, ,,	Epidermoid carcinoma.
			Ears slightly thickened	—	—	*Right fore foot* middle digit shows swelling	—	—	—
		—	—	—	—	*Nose* right side slightly thickened	Diffuse enlargement on right side of *nose*	28632 Killed for P.M. 21/12/42	Epidermoid carcinoma.
	33	*Left lower eyelid* swelling ½ cm. with scab	*Right lower eyelid* slightly roughened	*Left lower eyelid* nodule enlarged and bleeding	—	*Left lower eyelid* neoplasm markedly enlarged and bleeding	*Left eye* completely closed by the neoplasm with tendency to bleed	28631 Killed for P.M. 21/12/42	Epidermoid carcinoma.
		—	*Right ear* small buttonlike thickening	*Right lower eyelid* slightly thickened	*Right ear* buttonlike swelling		*Right ear* wartlike new growth	—	Epidermoid carcinoma (early lesion).
		—	—	—	—	—	*Right ear* wartlike new growth	—	Epidermoid carcinoma (early lesion).
		—	—	—	*Left ear* slightly thickened	—	Neoplasm *left ventral aspect of the neck*, near angle of the jaw	—	Ulceration of the cornea left eye.
		—	—	—	—	—	—	—	Epidermoid carcinoma.

TABLE I (*continued*).

Group.	No. of Rat.	Naked-eye Characters.						Specimen No.	Diagnosis.
		12/8/42.	4/9/42.	28/9/42.	9/10/42.	15/11/42.	21/12/42.		
	31	Died of sunstroke on 29/11/41.							
	65	Died of sunstroke on 31/11/41.							
	58	—	Opacity right *cornea*	*Left lower eyelid* slightly roughened	*Right upper eyelid* red nodule	—	Neoplasms both eyelids, ulcerating	28630 Killed for P.M. 21/12/42	Epidermoid carcinoma early lesions.
		—	—	*Ears* thickened wartlike growths		*Left ear* markedly thickened with horny growth—tendency to bleed	Both ears markedly enlarged, bleeding	28630 Killed for P.M. 21/12/42	Epidermoid carcinoma.

TABLE II.

Group.	No. of Rat.	12/8/42.	4/9/42.	28/9/42.	9/10/42.	15/11/42.	21/12/42.	Specimen No.	Diagnosis.
A2, exposed for 4½ hours daily (full diet)	38	*Right lower eyelid*, red swelling	Neoplasm about 1½ cm. in diameter, bulging, bleeding surface, completely closes the eye	—	—	—	—	28257 Killed 14/9/42 for P.M.	Epidermoid carcinoma.
	56	*Left lower eyelid* slightly roughened	—	—	*Left upper eyelid* slightly thickened	Further increase in size of nodule on eyelid	*Left eye* completely closed by a protruding reddish neoplasm 2·5 cm. in diameter, bleeding	28684 P.M. 31/12/43	Epidermoid carcinoma.
	46	*Right upper eyelid* slightly roughened	—	—	—	—	7/1/43. *Right lower eyelid*, small nodule	28814 P.M. 3/2/43	Epidermoid carcinoma, early lesions.
		Left lower eyelid slightly roughened	—	*Left lower eyelid*, small red nodule	—	—	*Left lower eyelid*, large neoplasm	—	Epidermoid carcinoma.
		—	*Ears* slightly thickened	—	—	—	Cornea ulcerated	—	—
		—	—	—	—	—	Nodules right and left ears	—	Epidermoid carcinoma, early lesions.
		—	—	—	—	—	*Nose* diffusely enlarged, ½ cm. in diameter disfigured	—	Epidermoid carcinoma.
	51	*Left lower eyelid*, small pink nodule	—	Neoplasm well developed	—	Neoplasm much enlarged and bleeding	—	—	Found dead on 16/11/42, neoplasm eaten by other Rats.
		—	—	*Right upper eyelid* thickened	—	—	—	—	—
	63	Died, heat stroke 31/1/42.							

TABLE III.

Albino Rats exposed Daily for 2½ Hours to Sunlight from 7.10.41 (With a Control Group kept in the Shade.

Group.	No. of Rat.	Date of Death.	Specimen No.	Remarks.
Group B1 exposed *for 2½ hours* from sunrise (on restricted diet)	30	5/6/43	29284	Pneumonia.
	38	2/9/43	—	
	48	—	—	Discharged.
	61	2/10/43	29765	Spindle-cell sarcomata lung, liver, omentum, right ear slight widening of epidermis.
	66	22/12/42	28633	
Group B2 exposed for 2½ *hours* (on full diet)	34	—	—	Discharged.
	41	2/9/43	—	—
	44	8/8/43	29521	Pneumonia.
	50	26/8/43	—	Pneumonia.
	60	18/5/43	29215	Both ears with nodules, one with *hyperkeratosis* and early stages of epidermoid carcinoma.
Group C1 *in shade* (on restricted diet)	40	2/6/43	29272	Pneumonia.
	43	—	—	Discharged.
	53	5/6/43	29283	
	55	12/4/43	—	Pneumonia.
	64	22/12/42	—	—
Group C2 *in shade* (on full diet)	35	1/3/43	28910	Pneumonia and abscess on head.
	39	2/3/43	—	—
	45	2/4/43	29070	Pneumonia.
	49	6/4/43	29071	Pneumonia.
	59	16/4/43	—	—

TABLE IV.

Albino Rats exposed to Sunlight from 1.4.42 *(with a Control Group kept in the Shade.*

Group.	No. of Rat.	Date of Death.	Specimen No.	Remarks.
Group Ao, exposed *for* 4½ *hours* (on restricted diet)	16	7/1/43	28709	Pneumonia; neoplasm right ear 2 cm.
	31	23/6/43	29356	diameter: Epidermoid carcinoma with haemorrhage and ulceration.
	35	6/9/43	29626	Horny outgrowth left ear, 3 cm. in diamter: Epidermoid carcinoma with necrosis.
	39	21/9/43	29716	Wart-like growths both ears: One early lesion of epidermoid carcinoma with hyperkeratosis, one with inflammatory changes en necrosis.
	53	—	—	
	85	—	—	
Group A3, exposed *for* 4½ *hours* (on full diet)	9	—	—	—
	34	22/11/43	29950	Pneumonia; wartlike growth right ear: Early lesions of epidermoid carcinoma with hyperkeratosis.
	36	18/5/43	29213	—
	44	9/4/43	29949	Pneumonia; new growths nose and ear: Nose epidermoid carcinoma; ear early.
	49	17/9/43	29694	Pneumonia: abscess right inner ear: Lesions, laminated appearance and inflammation.
	56	24/11/43	29948	Pneumonia; new growths on ear: Early lesions of epidermoid carcinoma with hyperkeratosis.
Group Bo, exposed *for* 2½ *hours* (on restricted diet)	4	20/3/43	—	—
	5	—	—	Discharged.
	10	—	—	Discharged.
	15	11/5/43	—	—
	54	5/6/43	29282	Pneumonia.
	95	23/10/43	29838	Pneumonia.
Group B3, exposed *for* 2½ *hours* (on full diet)	1	—	—	Discharged.
	18	21/8/43	29568	Neoplasm scrotal region—Fibroblastic sarcoma.
	38	19/11/43	—	Pneumonia.
	43	9/10/43	—	—
	46	7/2/43	—	Pneumonia.
	48	14/5/43	—	Pneumonia.
Group Co, *shade* (restricted diet)	8	28/10/43	—	—
	11	10/5/43	—	—
	41	22/11/43	29946	Pneumonia.
	45	14/5/43	—	—
	50	18/5/43	29214	Pneumonia.
	51	29/7/43	—	—
Group C3, *shade* (full diet)	3	—	—	Discharged.
	6	17/9/43	29693	Pneumonia.
	19	14/7/43	—	—
	33	2/7/43	29393	Pneumonia.
	40	26/11/43	29945	Pneumonia.
	55	—	—	—

TABLE V.

Incidence of Neoplasms in Rats after Exposure to Sunlight.

Commencement of Exposure to Sun.	Group No.	No. of Rat.	Left Lower Eyelid.	Left Upper Eyelid.	Right Lower Eyelid.	Right Upper Eyelid.	Left Ear.	Right Ear.	Nose.	Left Foot.	Right Foot.	Neck.
7/10/41, 4½ hours.....	A1, 5 rats.....	54	—	+	—	—	+	+	+	+	+	—
		33	+	—	—	—	+	+	—	—	—	+
		58	—	—	—	+	+	+	—	—	—	—
4½ hours.....	A1, 5 rats.....	38	—	—	+	(Killed)						
		56	—	+	—	—	—	—	—	—	—	—
		46	+	—	+	—	+	+	+	—	—	—
		51	+	—	—	+	—	—	—	—	—	—
1/4/42, 4½ hours.....	A6, 6 rats.....	31	—	—	—	—	—	+	—	—	—	—
		35	—	—	—	—	+	—	—	—	—	—
		39	—	—	—	—	+	+	—	—	—	—
4½ hours.....	A3, 6 rats.....	34	—	—	—	—	—	+	—	—	—	—
		44	—	—	—	—	+	—	+	—	—	—
		56	—	—	—	—	—	+	—	—	—	—
7/10/41, 2½ hours.....	B2, 5 rats.....	60	—	—	—	—	+	+	—	—	—	—

Photo No. 1.—Rat A1/58. Growth with swelling of left ear, roughening of eye-lid (left view).

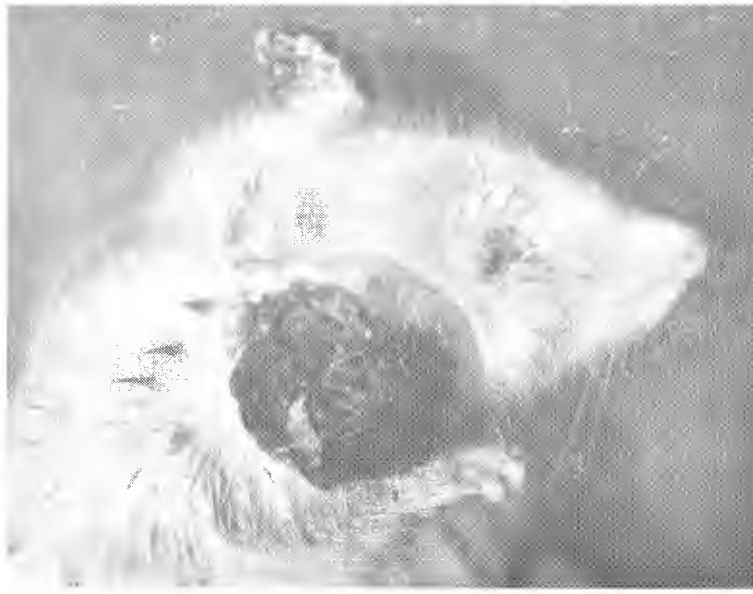

Photo No. 2.—Rat A1/58. Large cancer growth covering right ear, roughening of eye-lid (right view).

Photo No. 3.—Rat A1/56. Large cancer growth cover left eye.

Photo No. 4.—Rat A1/54. Cancer growths on left side of nose and right front foot.

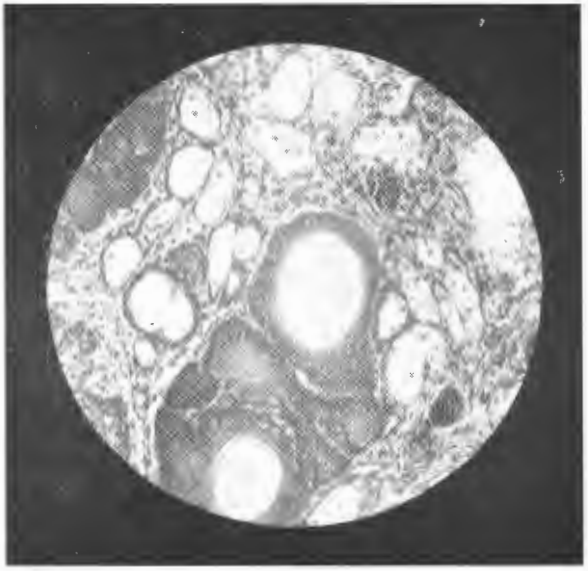

Photo No. 5.—Specimen 29215. Magnification 140×. Skin of rat. Note the characteristic hornifying squamous carcinoma.

Photo No. 6.—Specimen No. 28257. Magnification 140×. Skin of rat. Epidermoid carcinoma. Note the sarcoma-like nature of the cells.

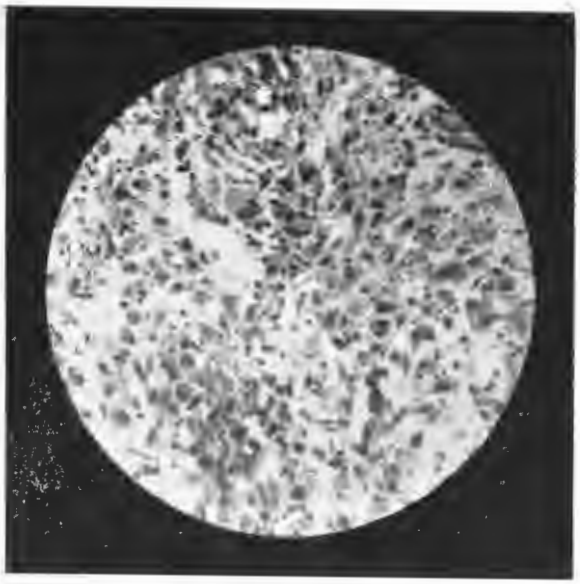

Photo No. 7.—Specimen No. 28631. Magnification 140×. Skin of rat. Epidermoid carcinoma. Note the variation in the structure of the cells.

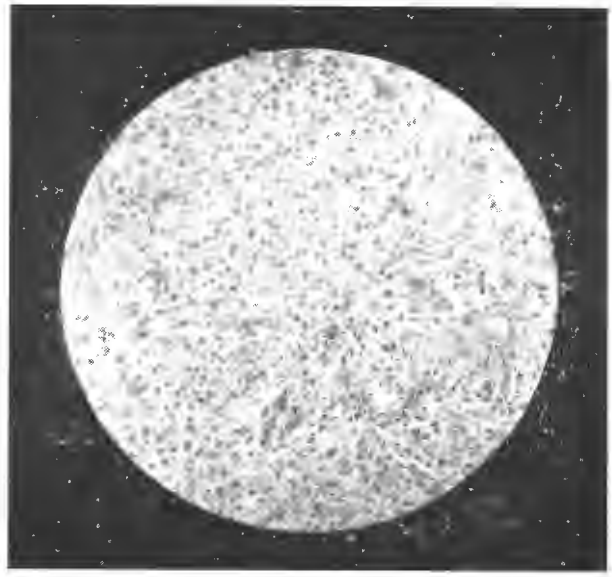

Photo No. 8.—Specimen No. 28631. Magnification 140×. Skin of rat. Epidermoid carcinoma. Note the variation in the structure of the cells.

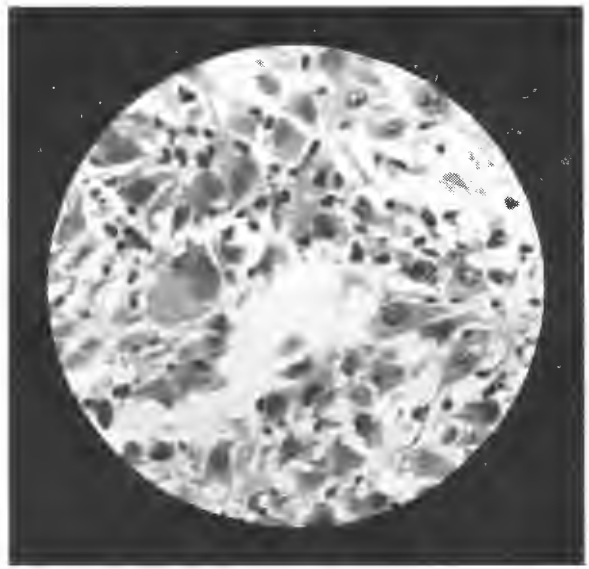

Photo No. 9.—Specimen 28631. Magnification 300×. Skin of rat. A slightly higher magnification showing the variation in the structure of the cells; some with more than one nucleus.