XLV. THE SUPPOSED INFLUENCE OF IRRADIATED AIR ON GROWTH.

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IN dealing with such a subject as the discomfort felt in close atmospheres, people are generally inclined to turn away from simple physical causes and find an explanation of their ill feelings in some mysterious quality such as the presence of an organic poison exhaled by people, or the ionisation of exhaled air. Physiological research while disproving the presence of any organic poison has shown that the influence of temperature, humidity, and movement of air on loss of body heat and moisture is very great, and that comfort can be secured by ventilation so arranged as to give an adequate cooling and evaporative power to the air. This can be measured by the dry and wet bulb kata-thermometer.

While any evidence as to the influence on comfort of ionisation of the air has been wanting Miss Hume and Miss Smith [1923] have recently published a paper in which they claimed that short daily exposures to air, which had been irradiated by ultra-violet rays, stimulated to some extent the growth of young rats fed on a diet deficient in vitamin A.

The evidence adduced in their paper is not strong when considered on a statistical basis, but the novelty of their claim excited general attention and, while ignorant writers in the Daily Press went so far as to say herein lay the explanation of the ill effect of tropical climates on white men, an engineer interested in this matter claimed no less that in some ionisation of air lay the explanation of the discomfort felt in the House of Commons, a discomfort which Leonard Hill in 1914 had shown to be due to the fact that the feet of the members were cooled by the current of air impelled through the perforated floor while their heads were made hot by immersion in a relatively stagnant warm atmosphere.

It may be mentioned here also that Kestner [1923] has claimed that anaemia experimentally produced in dogs is influenced beneficially by inhalation of gases coming from an arc lamp—he has even affirmed that the active gas is nitrous oxide¹!

In 1923 we gave the results of some experiments on growth of rats which were negative both as regards traces of ozone, oxides of nitrogen and tobacco smoke and irradiated air [1923]. We have carried further the experiments on irradiated air, detailed below, and have failed to find any positive results in these.

¹ Kestner moreover has asserted that the oppressiveness of a Sirocco wind is due to a fall of blood pressure produced by the presence of nitrous oxide in the air!

EXPERIMENTAL METHODS.

(1) *Lamps.* We have made use of two different quartz lamps: (i) An automatic lighting lamp made by Kelvin, Bottomley and Baird which takes 2 amps. at 200 volts. The amount of ozone produced is small, but the lamp is very active in other respects. (ii) A lamp with a six-inch tube made by the Hewettic Electric Co. This takes 3.5 amps. at 200 volts and its effective radiating surface was about six times that of the K.B.B. lamp. It was very active as an ozone producer. Both lamps were new when used for these experiments.

(2) *Animals.* Rats were used in all cases. In some experiments the young rats were taken directly from the Institute stock without regard to parentage; in other experiments pregnant females were taken from stock and fed on a diet rich in vitamin A, during the later stage of pregnancy and throughout the period of lactation. The rats commenced their irradiation treatment the day after they were put on the diet deficient in vitamin A.

The rats were kept in the laboratory singly in large glass jars, 8 litres in capacity, with wire covers and were bedded on sawdust. In one experiment cotton-wool replaced the sawdust as bedding.

(3) *Diet.* The diet used had the following composition:

					<i>Salt mixture</i>	
Caseinogen	...	...	...	18 parts	NaCl	5.2
Rice starch	...	...	...	52 "	MgSO ₄	16.4
Hydrogenated cotton seed oil	...	...	...	15 "	NaH ₂ PO ₄	10.4
Marmite	...	...	...	5 "	K ₂ HPO ₄	28.6
Lemon juice	...	...	...	5 "	CaH ₄ (PO ₄) ₂	16.2
Salt mixture	...	...	...	5 "	Ferric citrate	5.9
					Ca lactate	18.3

The caseinogen was the "edible casein" of commerce and was purified by (1) repeated extraction with boiling alcohol followed by extraction with ether, (2) heating in shallow zinc dishes to 102–105° for 72 hours, (3) a combination of both these methods.

The caseinogen, starch and salt mixture were first thoroughly mixed in a large mortar in a dry condition, then the melted fat was well kneaded in and finally the whole mixed into a stiff paste with the marmite, lemon juice and water. The diet was prepared fresh daily, and the rats were fed *ad libitum*. The lemon juice was expressed from the pulp of fresh lemons and was not decitrated or treated in any way.

The animals were weighed twice weekly in a tared vessel on a laboratory balance sensitive to 0.2 g.

Exp. 1. See Chart 1. Six young white rats about 50 g. each taken from stock, and divided into three groups of two each. The first pair were controls and received the diet deficient in vitamin A only; the second pair also received

10 minutes irradiated air daily, and the third pair 20 minutes irradiated air daily.

The irradiation was performed as follows: the rat was taken out of its jar and the sawdust was removed and the jar cleaned and taken to an adjoining room where the lamp was running; the jar was placed in the vertical position right under the lamp, the mouth of the jar being within two inches of the quartz burner. The jar was left there for a period of ten minutes and then quickly closed with a tight fitting glass lid and rapidly removed to the next room. Here the lid being opened slightly, the rat was quickly introduced and the lid then closed again. The rat remained in the closed jar for ten minutes after which the lid was taken off and the bedding and food replaced. This operation was repeated daily. In the case of the 20 minutes' exposure experiment, this was done twice a day.

Chart 1.

This experiment lasted seven weeks and the lamp used was the Kelvin, Bottomley and Baird.

Reference to Chart 1 shows that the irradiated air was without effect on the growth of the rats. The variations of the curves were well within normal limits.

Exp. 2. Chart 2. Four young stock rats about 50 g. weight; one used as a control; one given irradiated air; one directly exposed to the rays of the lamp for a period of five minutes daily at a distance of two feet from the lamp—after two weeks of this treatment the exposure was increased to 10 minutes daily and finally for the last six days the distance from the lamp was shortened to 12 inches. To the diet of the fourth rat 3 % of cod-liver oil was added in place of an equivalent amount of the cotton seed oil. The same technique was used for the irradiated air as described in Exp. 1 except that the jar used had a capacity of 13 litres. The period was 10 minutes daily.

The experiment lasted five weeks and was then discontinued. Reference to the growth curve shows several features of interest. First, the powerful

effect of the cod-liver oil. This rat reached a weight of 175 g. in five weeks. Secondly, the very poor growth of the irradiated air rat compared to the control; in fact, the control rat grew so well that the caseinogen was suspected of being insufficiently purified, and was subjected to a further process of extraction or oxidation without, however, any effect on the growth of the controls. These rats must have had a good initial store of vitamin. The absence is noteworthy of any effect on growth of the direct rays of the lamp—as compared with the control—but we lay no stress on this, as both control and rayed rats were still growing when the experiment was stopped. If by chance we had used the irradiated air rat as a control and *vice versa*, a result in favour of the latter would have been apparent. Individual differences must be ruled out by a sufficient number of experiments.

Chart 2.

Exp. 3. Chart 3. In this experiment, four rats from the same litter were used. During lactation the mother was fed on a diet of bread, milk, green-stuff, egg-yolk, and cod-liver oil. The irradiation was carried out by a somewhat different method in this experiment. A large bell jar about 3 litres capacity was used. It had two openings at the top one inch in diameter and could be closed at the bottom by a ground glass plate. After placing the rat in the jar and sealing the bottom with the glass plate the air from the vicinity of the burning lamp was sucked through the jar continuously by means of a filter pump. A short piece of india-rubber tubing (1 inch in internal diameter) was set from within an inch of the quartz lamp to the inlet of the jar. The outlet was closed with a rubber cork containing a tube running to the bottom of the jar and attached to a water pump. The actual length of the other tube

between lamp and jar was 12 inches. The jar was shaded from the light of the lamp.

By this means a continuous stream of irradiated air was sucked through the jar traversing only 12 inches of wide rubber tubing before entering the jar. One rat was kept in this apparatus 15 minutes a day and another rat was kept there 45 minutes a day. During the rest of the time the rats lived in their usual glass jars. A third rat was used as a control and the fourth was exposed to the direct rays of the lamp for a period of ten minutes daily at a distance of two feet; on the 21st day of the experiment the distance was shortened to one foot, and exposures were continued at this distance for the remainder of the experiment.

Chart 3.

Reference to the growth curve, Chart 3, shows that all four rats fall within the normal limits of a group of rats fed on a diet deficient in vitamin A. The irradiated air rats again fail to show the great increase in growth claimed by Hume and Smith.

As the fact that the rat receiving the direct rays of the lamp failed to grow better than the others was surprising, it was decided by one of us (T.A.W.) to see if the Ca and P content differed in any way from that of the other rats. The four rats were killed and the viscera removed and the carcasses were then ashed and a phosphorus determination made. The results are as follows:

Control rat	0.469 g. P or 55.6 mg. per g. of rat
15 minutes R.A.	0.487 g. P or 53.5 " "
45 minutes R.A.	0.513 g. P or 55.1 " "
M.V.L.	0.595 g. P or 67.6 " "

It will be seen that the rat subjected to the direct rays of the lamp contained a significantly greater amount of P than the other rats. The direct rays of the lamp had excited their well-known antirachitic effect, without any significant effect on the growth of the animal.

It has been shown by Korenchevsky [1921], and Goldblatt [1923] that the bones of rats fed on the -A diet used here do not have a normal calcium phosphate content. The diet is rather low in calcium.

It should be stated that none of the rats showed any macroscopic signs of rickets—the predominating feature in autopsy being the almost complete absence of subcutaneous fat.

The K.B.B. lamp was used in this experiment and the rats bedded in cotton wool.

Exp. 4. Chart 4. In this experiment six rats of a litter of seven were used. The mother was fed on diet rich in vitamins three days before the birth of the litter and this rich diet was continued until the experiment was started.

The litter was divided into three groups of two each. One group was used as controls, one for treatment with irradiated air and one for treatment by the direct rays of the lamp.

Chart 4.

The irradiated air treatment was carried out as in Exp. 2, a 13 litre jar being used, the period being ten minutes daily. The direct raying of the rats was 15 minutes daily at a distance of two feet from the lamp. The lamp used was the large lamp made by the Hewettic Electric Co. The rats used varied in colour as follows: irradiated air treatment; one white and one black and white; controls; one black and white, and one sable; direct raying with M.V.L.; one white and one dark brown; this brown rat very much resembled a wild rat except for a few white patches on its belly.

The experiment lasted seven weeks and the results are shown in Chart 4. The irradiated air rats again show no growth response but the rats exposed directly to the rays from the lamp appear to show a distinct growth response. This is more noticeable in the case of the brown rat. As it is well known

that this type of rat grows better than the albino rat, we cannot assert that this deeply pigmented rat shows better growth in response to radiation than the albino rat.

We are making further investigations into this question of pigmentation and light effect.

DISCUSSION.

In no case have we been able to confirm the results of Hume and Smith regarding the growth-promoting effects of irradiated air and we have come to the definite conclusion that it has no effect on growth, nor do we see any possible *a priori* reason why it should have an effect on growth.

A daily exposure of 15 minutes to the rays of a 3.5 ampere lamp at a distance of two feet appears to have some stimulating effect on the growth of young rats on a diet deficient in vitamin A, but a daily exposure of ten minutes to a 2 ampere lamp apparently has no effect on growth although it exercises a considerable effect on the calcium and phosphorus metabolism. Evidently the ultra-violet rays do not stimulate growth by preventing rickets as suggested by Steenbock and Nelson [1923]. The radiant energy necessary to promote growth appears to be other than that required to cure rickets.

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