Neither stone in the bladder nor gravel, or cystitis, or any abnormality of the urinary tract was found at *post-mortem* examination in any of these 18 animals.

CONCLUSION.

The addition of whole milk, in the proportion of two-thirds of an ounce per rat daily, to a diet capable of causing urolithiasis in 50 per cent. of young rats, completely prevented the development of phosphatic calculi.

THE BACTERICIDAL ACTION OF LIGHT ON TUBERCLE BACILLI.

BY

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THE value of ultra-violet rays in the treatment of lupus vulgaris is well established, but the mechanism of their mode of action is still a matter of controversy. Some maintain that the local application of light produces direct bactericidal action in the depths of the lupus nodule. If there is no direct bactericidal action of these rays, some general effect on the whole body or the local effects of irradiation must be responsible for the results and cures which have been obtained.

While bacteria can be readily destroyed by exposure to light, the culture medium, the depth of layer of fluid, the age of the culture, the intensity of light, and temperature are all important factors. Coliform bacilli suspended in Ringer's solution are readily destroyed by long ultra-violet rays, staphylococci by short rays, while, according to Weisner,¹ the Friedländer pneumo-bacillus is resistant to light owing to the mucous envelope surrounding the organism. Robert Koch² found that cultures of tubercle bacilli were destroyed by prolonged exposure to sunlight which passed through the window glass of his laboratory. J. Bang showed the bactericidal action of the concentrated Finsen light on the tubercle bacillus, and the *Staphylococcus pyogenus aureus*. Mme V. Henri³ and Baroni investigated the effects of irradiation of tubercle bacilli with the mercury quartz arc, and found that the bacilli lost their acid-fast staining reaction after three to four minutes' exposure, and were destroyed after ten minutes. Kattenbracher found that tubercle bacilli were readily killed after five to sixty seconds' exposure to the iron arc. Such experiments have definitely proved the bactericidal action of ultra-violet rays on the tubercle bacillus, but in the case of sunlight the effect of ultra-violet rays has not been clearly separated from heat effects. Thus, results obtained from the experiments of Mitchell and Crough,⁴ von Bergen, Triskanokaja, and Fr. Krusius show variations in the lethal time from half an hour to six hours.

While concentrated solutions of tuberculin are resistant to light,⁵ solutions of 1 in 1,000 concentration can be weakened by exposure to rays shorter than 3,250 A.U. Recently W. Hausmann,⁶ W. Neumann, and K. Schubert have shown that inoculations of irradiated tuberculin do not give rise to any local reaction, but the usual general reaction is obtained.

As the review of the literature indicated that the tubercle bacillus can be destroyed by ultra-violet rays, but failed to demonstrate the selective region, further investigations were carried out. Surface scrapings of a fourteen-day culture of tubercle bacilli (a virulent bovine strain obtained from Captain S. R. Douglas) were placed in a sterile test tube; 250 mg. of this culture were mixed with 250 c.cm. of sterile saline, and quantities of 50 c.cm. of the mixture were placed into sterile vaccine bottles and sealed off.

EXPERIMENT 1.—Control.

Four guinea-pigs were inoculated subcutaneously into the right thigh with 1 c.cm. of the suspension of tubercle bacilli in saline (dose=1 mg. of tubercle bacilli). The animals were kept under observation, and the time of the appearance of a hard swollen inguinal gland was recorded. Forty-one days after inoculation all the animals were killed and *post-mortem* examinations were performed. All these animals had generalized tuberculosis.

EXPERIMENT 2.—Exposure of Tubercle Bacilli to Mercury Vapour Lamp (7,620-2,300 A.U.)

Of the emulsion of tubercle bacilli in saline 15 c.cm. were placed in a sterile quartz flask. The flask was attached to an electric motor and was exposed to two mercury vapour lamps (K.B.B. type, 2.5 amperes, 210 volts, D.C.) eight inches distant. The flask was slowly rotated during the exposure, so that a thin fresh film of fluid was constantly exposed to the lamp. The flask was kept cool during rotation by a trough filled with cold water. At intervals of 5, 10, 15, 30, and 60 minutes samples of the suspension of the irradiated bacilli were removed from the flask and 1 c.cm. of each specimen inoculated into a guinea-pig. The experiment began on December 20th, 1926, and ended on January 31st, 1927, when the animals were killed.

Time of Exposure to Lamps.	Weight.	Weight when Killed.	Result when Killed.
	Grams.	Grams.	
5 minutes	5.0	—	Died December 24th, 1926; ? cause pneumonia.
10 "	330	520	No evidence of tuberculosis.
10 "	330	600+	Small caseous gland 2 by 0.5 by 0.5 c.m.
15 "	370	590	Healthy when killed.
15 "	450	590	No histological evidence of tuberculosis.
30 "	310	420	
30 "	510	600+	
60 "	390	430	Healthy.
60 "	410	510	

Conclusion.—The tubercle bacilli suspended in saline are destroyed after 10 minutes' exposure to the radiations (7,620-2,300 A.U.) of the mercury vapour lamp.

EXPERIMENT 3.—Exposure of Bacilli to Mercury Vapour Lamp (Filtered).

Tubercle bacilli were exposed as in experiment No. 2 to radiations of a quartz mercury vapour lamp, but filtered through a screen of vitaglass (radiations=5,720-2,800 A.U.). The experiment began on December 12th, 1926, and ended on January 31st, 1927, when the animals were killed.

Time of Exposure to Rays.	Weight.	Weight when Killed.	Result when Killed.
	Grams.	Grams.	
5 minutes	350	450	Two small caseous glands 1 by 0.5 by 0.7 cm., and 1.5 by 0.5 by 0.7; otherwise nil.
5 "	300	360	Big caseous glands; nodule in spleen.
10 "	375	560	Small caseous inguinal gland.
10 "	330	540	Small caseous inguinal gland 1 by 0.5 by 0.5 c.m.
15 "	420	550	Nil.
15 "	390	390	Small caseous inguinal gland 1 by 0.75 by 0.5 cm.
30 "	350	600+ (pregnant)	Nil.
30 "	325	470	Nil.
60 "	380	510	Nil.
60 "	360	570	Nil.

Conclusions.—The tubercle bacilli in saline are destroyed or attenuated after 30 minutes' exposure to the rays (5,720-2,800 A.U.) of the mercury vapour lamp filtered through a sheet of vitaglass, which allows the passage of rays from 5,700 to 2,800 A.U. There was evidence of a local lesion at the site of inoculation in the right groin, in the animals injected with the tubercle bacilli exposed for 5, 10, and 15 minutes. When the animals were killed on January 31st, 1927, only one guinea-pig (No. 15) showed a macroscopic tuberculous nodule in the spleen. No macroscopic or microscopic evidence of the disease was found in the remaining animals, which were injected with suspension of bacilli exposed for 30 and 60 minutes.

EXPERIMENT 4.—Exposure of Bacilli to Mercury Vapour Lamp Through Window Glass.

The suspension of tubercle bacilli in saline was exposed to the rays of the mercury vapour lamp as in Experiment 2, but through a screen of window glass (radiations = 5,720-3,300 A.U.). At intervals after 5, 10, 15, 30, and 60 minutes' exposure samples

were removed from the flasks and inoculated subcutaneously into guinea-pigs. The experiment began on December 20th, 1926, and ended on January 31st, 1927, when the animals were killed.

Time of Exposure to Rays 5,720-3,300 A.U.	Weight in Grams.	Weight when Killed.	Result and Remarks on Post-mortem Examination.
5 minutes	315	320	Generalized tuberculous nodules in spleen, liver, lungs, and glands.
5 "	310	440	" "
10 "	510	530	" "
10 "	258	350	" "
15 "	350	500	" "
15 "	325	420	" "
30 "	360	530	" "
30 "	250	390	" "
60 "	380	450	" "
60 "	375	510	" "

Conclusions.—These rays (5,720-3,300 A.U.) have no lethal action on tubercle bacilli in saline after 5 to 60 minutes' exposure.

Experiment 5.—A second control experiment on four guinea-pigs showed the virulence of the tubercle bacillus suspended in saline and kept in the cold room at 5° C. for twenty-four hours.

Experiment 6.—Another control experiment showed the virulence of the tubercle bacillus suspension mixed with an equal quantity of rabbit's defibrinated blood.

Experiment 7.—A third control experiment showed the virulence of the tubercle bacillus suspension mixed with an equal quantity of rabbit's serum.

Experiment 8.—A suspension of tubercle bacilli in saline, mixed with defibrinated blood, was exposed to ultra-violet rays as in Experiment 2. All the animals showed tuberculous lesions.

Experiment 9.—A similar experiment was carried out with the irradiated mixture of suspension of bacilli and rabbit's serum and with like result.

Conclusions.

Tubercle bacilli mixed with blood or serum exposed in a very thin film are not killed.

Similar experiments carried out with mixtures of defibrinated rabbit's blood and staphylococci have shown that bactericidal action is noticeable after half an hour's irradiation of the thin blood film, and complete destruction of the cocci after one hour's exposure.

These experiments afford evidence that rays shorter than 3,300 A.U. are the most bactericidal on the tubercle bacillus. The long ultra-violet rays from 4,000 to 3,300 A.U. were without effect. Since the penetration of shorter rays is small, it is doubtful whether local bactericidal action occurs *in vivo* with either the local Finsen lamp or the Kromayer types of local treatment lamps. The fact that the whole range of rays from 5,760 to 2,300 emitted from the mercury vapour lamp cannot destroy tubercle bacilli in a thin blood film, even after one hour's exposure, strongly supports this view. Nagelschmidt⁶ inoculated guinea-pigs with extracts of tuberculous tissue which had been irradiated with the local Finsen lamp; he claimed that the animals inoculated with the irradiated tuberculous tissue survived, while control animals inoculated with unirradiated tissue died. Klingmüller and Halberstadter⁷ irradiated lupus nodules for seventy minutes with a Finsen concentration lamp and injected ground extracts of the irradiated lesions into the peritoneum of guinea-pigs. Some of these animals died later from tuberculosis. Similar experiments were carried out with virulent tubercle bacilli injected subcutaneously and intradermally, and the site of inoculation was immediately irradiated, but later all the animals were found to be suffering from generalized tuberculous disease. They concluded from their experiments that the local Finsen light treatment had no local bactericidal action, even when the tubercle bacilli were situated comparatively near the surface. H. Jansen⁸ has found that the rays from the Finsen lamp can completely destroy tubercle bacilli in a lupus lesion to a depth of 0.15 mm., but the lupus nodules are usually situated 2 to 4 mm. below the skin surface. Karl Sonne and Axel-Reyn both state that the increased skin temperature which is produced with local irradiation sup-

ports the researches of Thiele and Wolf, that at higher temperatures longer wave-length rays can exercise bactericidal action. Seeing that tubercle bacilli mixed with blood or serum are not destroyed *in vitro*, it seems very improbable that any irradiation with the mercury vapour lamp of tubercle bacilli *in vivo* can result in a direct bactericidal action. With many of the lupus lesions the extensive scar tissue, ulceration, and desquamation render a lethal action still less probable. The local Finsen light, by overheating the part, may, however, have some bactericidal action.

The cure of lupus vulgaris by means of local irradiation must be due chiefly to tissue reaction. The histological changes following the irradiation of lupus lesions have been studied by R. Gassul, and indicate an inflammatory reaction in the early stages and, later, necrosis of the chronic granulomatous tissue with the formation of new connective tissue. Many theories have been advanced to explain the results which have been obtained, but no definite experimental proof has been yet described which can explain the reaction of the tissues following the general irradiation of the skin of the body, or the local application of the rays to the site of a tuberculous lesion. While the chronic tuberculous diseases of the skin and mucous surfaces respond admirably to ultra-violet radiation, the tubercle bacillus is an organism which is more resistant to the rays of the mercury vapour lamp than the staphylococcus, and apparently is only sensitive to the shorter ultra-violet rays, and from these *in vivo* it is protected by the tissues.

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Memoranda:

MEDICAL, SURGICAL, OBSTETRICAL.

TUBAL ABORTION AND RUPTURE.

AFTER reading Dr. Connell's most interesting paper on tubal abortion and rupture (June 4th, p. 1004) I felt that the following case might be of interest, as it differs so completely from other cases which have fallen to my lot.

Early on August 28th, 1926, I was called to see a married woman, aged 32, with one child aged 2 years. She gave a history of several similar attacks. On this occasion she had awakened at 5 a.m. with severe abdominal pain. Her husband gave her some brandy, which failed to ease her. A period had started two days previously; it was a week overdue. She had always been quite regular until this occasion. The loss was much the same as usual. Her colour was good, and there was certainly no pallor. The temperature was normal, and the pulse 80. There was pain and tenderness in the right iliac fossa. I persuaded her to come into hospital for observation. Internal examination added nothing to my knowledge. She was given an enema. The result was good, and she felt much better. I assumed that the appendix had emptied itself and settled down. That evening I found her sitting up in bed, chatting quite happily to the matron and feeling almost well. The next day she felt quite well. The second day after admission—at the end of four days—the period stopped, which she considered normal. She had no further loss. She asked me to remove the appendix as she had had so many of these attacks, stipulating that I should remove it even if it looked normal. I told her that I expected it would look normal after such a slight attack, and promised to remove it. She kept perfectly well until the operation on September 4th. When I reached the peritoneum I saw free blood on the other side of it. I opened the peritoneum, removed the appendix, which was fairly normal—it had a kink—closed the wound, and started afresh in the middle line. There was plenty of free blood as usual. When the uterus was got up I found to my surprise that it was the left tube which had ruptured. I removed it, and a very small foetus. The patient made a very good recovery.

The points which seemed most striking were that the onset of bleeding and pain did not synchronize more closely, and that when I saw her between three and four hours from the onset of the pain there was no pallor or collapse. It is true that she had had some brandy. Her highest temperature was 98.8° F. on the evening of her admission to hospital, and I should have expected more from peritoneal irritation by the free blood. The signs and symptoms pointed to the right side, and the ruptured tube was the left.

Wisbech.

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