It is always present, and confined to those parts of the walls of the labyrinth which are studded with warts, there forming a dense carpet, which gives the dark colour to the walls. The ant, *Iridomyrmex myrmecodiae*, which inhabits the tubers under natural conditions is a small red one, but this was dispossessed by a larger black species in plants under cultivation in the garden of Buitenzorg.

The two kinds of wall-surface are thus briefly characterised:—" One part is smooth, light brown, impervious to water, free from fungus, and on which alone the ants place their pupæ; the other part is warty, discoloured, pervious to water, clothed with fungus, and never bears pupæ." Further, the ants deposit their excrement exclusively in the fungus galleries, so that the breeding part is kept pure and clean. Although a system of galleries and chambers is developed under artificial conditions independently of ants, the association of the three organisms points to a beneficial symbiosis whereby nutrition of the host plant is supplemented and the ants are provided with a home.

W. BOTTING HEMSLEY.

THE STUDY OF DAYLIGHT ILLUMINATION.[1]

PROF. L. WEBER has lately published an account of the series of tests of daylight illumination carried out by him in Kiel during the years 1905–8. Measurements of this kind were previously undertaken and described by the author so far back as 1890; his main object on this occasion has been to devise a more accurate and convenient means of specifying daylight illumination and the requisite window-area in interiors.

The results of a new and complete series of measurements of light from the unrestricted sky, carried out at mid-day, classified for the months of the year and extending over the years 1905–8, are now given. The author also describes an improved form of photometric apparatus specially devised for this work. The results of an extensive series of tests of the day-illumination in the State schools at Kiel are also presented. At the time of previous experiments the individual characteristics of the various class-rooms and the prevailing climatic conditions had not been sufficiently correlated, so that it was difficult to frame very precise general recommendations. Prof. H. Cohn has, however, suggested that the illumination on any desk should not fall below 25 metre-candles (approx. $2\frac{1}{2}$ foot-candles), and that this result would in general be secured if the projected solid angle subtended by the window-area at this desk was not less than 50 square degrees.

This solid window-angle is often taken as the sole criterion of effective illumination. Yet it leaves out of account the effect of reflection from the walls in the room, and also the position of the window with respect to the surroundings outside.

An improvement now suggested by Prof. Weber takes the form of measuring the " light-value " (Lichtgüte) of the window. This quantity denotes the value of the projected area of the portion of the window-area which is entirely unobscured by surrounding trees or buildings, the area of the entire window being taken as 100. Prof. Weber describes two new instruments for the convenient measurement of these quantities.

Authorities, in estimating the daylight requirements of a room, usually require that the ratio of the window-area to the floor-area of the room should not exceed 1 : 6, or in some cases 1 : 10. The author suggests that if this ratio were multiplied by the " light-value " we should get a much more serviceable factor (which he denotes by P) for expressing the admission of light to the room.

Further data are needed before one can state quite definitely what value P should assume for various interiors, but this information could readily be obtained. As an illustration the author summarises the results of tests in 520 typical class-rooms, the illumination on the best and worst illuminated desks, and on a desk intermediate between these extreme positions, being studied. For 171 of the rooms P had a value >10, and in 304 rooms it was >5 but <10. In conclusion, he estimates that in only 5 per cent. of these class-rooms would the illumination, under average climatic conditions, during the year fall below Cohn's minimum of 25 metre-candles.

Prof. Weber next gives an account of his examination of the conditions of illumination in the library of the University of Kiel. He shows that, so far from complying with Cohn's minimum figure, even the best lighted tables would only receive 2–3 metre-candles during December. He also points out that the rule prescribing the window space for a given floor-area is quite inapplicable to rooms in which the floor is filled by vertical stacks of books, and that such shelves rarely receive sufficient light.

Finally, there is a communication from H. Borchardt which contains a summary of the theoretical and experimental methods employed for studying the distribution of brightness in the sky. A chart (based on a method devised by Prof. Weber) is given showing the approximate intensity and distribution at different periods of the year. The sky rarely approaches the ideal diffusely radiating hemisphere assumed in conventional calculations. The illumination is really due to mixture of diffused and transmitted light, the proportions of which vary with different climatic conditions. The distribution of brightness alters accordingly.

[1] A reprint from the *Schriften des Naturwissenschaftlichen Vereins für Schleswig-Holstein*, Band xv., Heft i.

THE FLORA OF DAGHESTAN.

MR. N. I. KUZNETSOF concludes an article in the *Izvestiya* of the Imp. Russ. Geogr. Soc., Nos. 6–7, 1910, on the flora of the mountain region of Daghestan, with an historical sketch of its origin and distribution. Daghestan was raised above the water at the beginning of the Tertiary period, and its climate subsequently became drier and assumed a more continental character as the Sarmatic Sea around it dried up, and consequently the Tertiary forest which clothed it must have gradually dwindled. At the same time, the combined action of erosion and tectonic movements produced bare slopes, which, especially those facing south, afforded excellent conditions for the development of upland xerophytic vegetation. Here gathered forms which had existed in various parts of Daghestan from the beginning of the Tertiary period, and were now distributed, some in the north, others in the south, some on the schists, others on the limestones, and in connection with climatic conditions.

In the Glacial period Daghestan received fresh accessions from the north, and from the west through Asia Minor. Firs and birches now clothed the country, crowding out what was left of the Tertiary timber trees, which are now represented only by an occasional Tertiary birch, *Betula Raddeana*, or oak, *Quercus macranthera*. Many slopes, especially the southern, were never forested, and many limestone plateaus would not harbour arboreal vegetation, and there xerophytic types spread vigorously.

In the steppe period the forest trees retired into the heart of the country, their place being taken by xerophytic forms, while in the open valleys appeared representatives of the hot desert flora of the Mediterranean. The mountain xerophytic forms of Daghestan spread widely during this period. Some forms, not adapted to migration, remained in the country, others spread to other parts of the Caucasus, while those easily distributed extended so far as the steppes of South Russia, when these were laid bare by the retreat of the Pontic Sea. Maps accompanying the article show the distribution of the most characteristic forms.

VITAL EFFECTS OF RADIUM AND OTHER RAYS.[1]

ADOPTING the chronological order in which the radiations of radium and other sources were discovered and applied, the lecturer considered, in the first place, the effects of light and radiant heat, dwelling especially upon the fact that the chemical rays—*i.e.* blue, violet, and ultraviolet—were those which had vital effects upon the tissues. The differential effect of these rays as compared with those of longer wave-length at the other end of the

[1] Abstract of a discourse delivered at the Royal Institution, on February 2, by Sir James Mackenzie Davidson.

spectrum was well brought out in the course of an experiment in which, the spectrum having been produced upon the screen, a strip of bromide paper was stretched across it so as to receive the length of the spectrum, and this on being developed and fixed was shown to have darkened very considerably at the blue and violent portion, while the red end of the spectrum was practically white paper. The more ready absorption of these blue and violet rays, known to everyone who has looked at the reddened disc of the sun through a somewhat dense fog, was further illustrated by placing a glass cell in front of the lantern and filling it with hypo solution to which some hydrochloric acid was added. Ultimately, only the red waves were able to penetrate. The lecturer further pointed out that the blue colour was the last to be seen at the close of day; that when a person had his sight temporarily impaired by over-indulgence in tobacco he lost the perception of red and green in the centre of his field of vision, but very rarely lost the perception of blue; and that in cases of blindness coming on gradually from wasting of the optic nerve, blue was the last colour to go.

After reviewing the Finsen light treatment, which was based upon the fact that the most effective rays, physiologically speaking, were those of the violet and ultra-violet, and the superseding of the arc by a quartz mercury vapour lamp for the production of active violet light in large quantities, the lecturer turned to the X-rays, and spoke of the early X-ray burns sustained by operators, paying a tribute to Dr. Blacker, of St. Thomas's Hospital, one of the first martyrs in radiology. Sir James proceeded:—

"It is worthy of note that most, if not a'l, X-ray burns produced in operators began in the uncovered parts of their skin, such as the hands and face. A good deal of doubt still exists as to whether the primary X-rays alone are responsible for these manifestations. Having suffered from chronic X-ray burns in my hands, especially my right hand, it seemed to me rather remarkable that the area of trouble at the back of the hand should end sharply at a line corresponding to the usual position of the coat-cuff, for cloth, of course, is quite transparent to the X-rays, and the adjacent parts of the skin beneath the sleeve were in my own case equally exposed with the uncovered hand itself.

"Many views have been put forward to explain the causation of certain of the X-ray burns, but it appears probable that the secondary or indirect rays given off from the surface of the glass may be, if not in some cases the primary factors, certainly largely contributory to these superficial skin burns. As a further confirmation of the possibly vital effect of these rays upon the skin, I may mention that Freund, of Vienna, found that a tube so high as to give no fluorescence on the screen caused the hair to fall out, and also that, with a tube having the electric current passed in the reverse direction so as to produce only very weak primary X-rays, similar results were obtained. It would be interesting to construct a tube so as to employ for therapeutic purposes these secondary rays alone."

The lecturer demonstrated the existence of these secondary and less penetrating rays by exciting a Crookes tube in the ordinary way, and suspending opposite the point from which the primary rays emerge a mass of lead through which no primary or direct X-rays could possibly penetrate. Naturally, a shadow of the lead was cast by the X-rays coming from a fine point in the anode—the X-rays which may, for the present, be called the primary rays—but within this eclipsed area he obtained shadows caused by other rays, and when these were traced they were shown to be produced on the glass of the tube, which fluoresced green. These rays, he found, were more richly produced in what was called a "high" or "hard" tube. On making comparative measurements of the rays by means of the electroscope, he found that with a high tube giving very penetrative rays, if the action of the primary rays were taken as 1, the action of the secondary rays would be $\frac{1}{2}$, and that with a low tube giving X-rays of a low order of penetrability, if the primary rays were again taken as 1, the secondary rays would be one-seventh.

The work done upon these secondary rays from the physical side is comparatively slight. Mr. Campbell Swinton alludes to their existence in a paper published in 1898, when he describes them as secondary rays from the green fluorescing glass of the X-ray tube; and at a somewhat earlier date Prof. Silvanus Thompson showed that the kathode stream, after impinging upon the target and thus giving rise to the main beam of X-rays, was reflected and impinged upon the glass walls of the tube, thus causing a green fluorescence. He called these reflected kathode rays "para-kathodic." "Whether they produce X-rays upon this second impact or not does not appear to have been proved," said Sir James Davidson in concluding this portion of his lecture, "but as Barkla and Sadler and others have demonstrated that X-rays outside the tube, impinging upon solid matter, give rise to secondary rays, it seems certain that the X-rays, in passing through the walls of the tube in which they are generated, must give rise to secondary X-rays, and it may well be the case that the green fluorescence of the glass of an X-ray tube gives us two sets of X-rays—one produced by the primary X-rays in their impact on passing through it, and the other produced possibly by reflected kathodal rays. Be that as it may—and it is a matter for the physicist—I feel sure that their physiological action upon the skin must be considerable, especially as they are much more readily absorbed than the primary X-rays."

Discussing the methods of protection against X-ray burns, the lecturer said that many years ago he made an experiment in which a Crookes tube was completely buried in a large quantity of red lead contained in a box, and when this was excited in a dark-room the fluorescent screen showed that no X-rays at all were able to penetrate. Then a small opening was made by scooping away the red lead until the primary rays got through, together with only a very few of the secondary rays from the small area of glass opposite the orifice. This was the most effective means of screening everybody from the rays except the individual under observation, but it was highly inconvenient, the apparatus being difficult to handle, especially when a fresh tube had to be embedded. Therefore a box was constructed, lined with a mixture of red and white lead, and a small hole was cut in it for the emission of the rays. Some such method, he added, was now generally adopted, and was most important for the protection of the workers. The lining of the fluorescent screen with thick lead-glass, and the Sabouraud pastille method of dosage, with other safeguards, rendered the X-rays, as applied for medical purposes, practically free from risk to operator and patient alike.

The lecturer then proceeded to describe the effects of X-rays upon cell-life, pointing out their radical influence upon the young and growing tissues. On the principle of attacking the young and growing cells, the X-rays injured the hair follicles and brought about the fall of the hair. The sweat glands could be destroyed in the same manner. The action of the X-rays upon the blood was limited chiefly to the white blood corpuscles, the red blood corpuscles being very resistant. The central nervous system also, fortunately, had great resisting capacity. The most sensitive of all the tissues were the lymphoid tissues generally, especially the spleen, which shrank and became strongly pigmented under the attack of the radiation. Indeed, in certain diseased conditions of the spleen the X-rays had been used with marked success. In malignant tumours, while the X-ray method might be of service in checking the rapidity of the growth, it could not be looked upon as a method of cure, although after the removal of such growths by operation the application of the rays to the involved area might assist in destroying any of the malignant cells which the surgeon's knife had missed, and thus preventing redevelopment. As the technique of the X-rays improved, the field of their utility in therapeutics would be gradually extended.

Next in order to the X-rays, historically, came radium. The events which led up to the discovery of this substance were summarised, and the physical properties of radium were described. The process of the disintegration of the radium atom, through which was evolved the radiant energy of such service in medicine, was admirably illus trated by the very simple experiment of burning some magnesium sparking compound. In this process of flying to pieces the radium atom first gave off an atom of helium which was called the α ray, and the remainder of the atom evolved as a gas or emanation. The emanation in its turn decomposed, losing half its energy in about four days, and finally gave rise to an active deposit of rapid change, which gave off α, β, and γ rays. The action of the α rays on living cells was uncertain, but from some experiments which the lecturer had carried out with the "active deposit" from thorium he thought that the action of these rays upon the skin must be very slight.

The biological effects of radium had been closely studied upon a large variety of organisms. In the case of plants, for instance, a tube of radium placed upon a leaf would cause the irradiated area to lose its chlorophyll and to assume autumn tints. A prolonged exposure retarded the growth of seeds. Anthrax microbes had been found not to develop at all if left for twenty-four hours in an atmosphere charged with radium emanations. In Metchnikoff's laboratory at the Pasteur Institute, recently, it had been proved that certain toxins tended to lose their virulence after being made radiferous. When diphtheritic toxin was left for thirty days in contact with minute quantities of radium sulphate, the poisonous effect of the toxin was found to be much less rapid than in the case of the same toxin which had not been treated in this fashion. Young animals were particularly sensitive, especially in the epithelial tissues, and when animals had been killed by exposure to radium it was worthy of remark that paralysis and death were found to be due to internal hæmorrhages. The nerve cells had not shown any appreciable alteration. The central nervous system in all cases, indeed, was very resistant to radium action, but it suffered indirectly from the effects upon the vascular tissues.

"The date of my own first application of radium to the treatment of disease," continued the lecturer, "was May, 1903. The case was a large rodent ulcer, just below the right eye, which was rapidly progressing in spite of X-ray treatment. Two glass tubes, each containing 5 mg. of radium bromide, were applied tentatively for a short time to the upper border of this ulcer, and the application was cautiously repeated in the course of two or three days. The improvement was so manifest that the tubes were applied in the same manner over the general surface of the ulcer, which finally healed perfectly without scarring, and has remained well during the nine years that have since elapsed." While incapable of effecting a cure in certain severe and old-standing rodents, their progress was arrested in a marked manner, and considerable improvement of the condition was gained. "Radium has also proved to have a markedly specific action upon a troublesome disease of the eyelids known as 'spring catarrh.' This occurs in young people, the upper eyelids more particularly being covered with rough granulations. The disease was quite incurable until I applied radium to a little boy sent to me by Mr. Arnold Lawson, and with the use of radium every case treated has been completely and painlessly cured. A matter also worthy of remark is that from the commencement of the treatment, even before any appreciable improvement is visible, the patients express themselves as feeling the eyes much more comfortable, and they are able to use them in their ordinary occupations during the period of treatment.

"A further indication for radium therapy was discovered in the case of X-ray dermatitis. It was my misfortune to suffer from a chronic manifestation of this trouble, and three or four years ago a burnt patch on my hand became ulcerated. One portion was so threatening as to suggest malignancy, which is, unfortunately, a common result of these lesions. As nothing that was tried would effect a cure, it became a question of excision; but before resorting to this I applied radium in glass tubes, and was agreeably surprised to find that it completely cured the condition. The tube contained 20 mg. of pure radium bromide, and was left in position for twenty-five minutes. Nothing happened for twelve days, and then there occurred a certain amount of swelling and redness, the size of the black crust increased, and serum exuded from the side. This gradually subsided, and when the crust peeled off the normal healthy thin skin was found to be beneath it." Some striking photographs illustrated successively the dermatitis, the radium tube in position, the reaction, and the disappearance of the spot.

The lecturer went on to describe the apparatus for spreading radium, for enclosing it in tubes of metal and embedding it in the tumour, and for its metallic filtration so as to obtain a desired penetrability of ray. Some diseases yielded to radium more readily than others. Lupus was very resistant, but a great many other skin diseases, as well as *small* cancers of the tongue and lip, could be cured, while large, rapidly growing tumours like sarcoma could be cured by the method of burying tubes within them. Here, again, the fact was illustrated that these rays seemed to concentrate their attack upon young and most rapidly growing cells. That was probably the reason why sarcomas were so vulnerable to attack when compared with carcinomas, which were of slower growth. But in spite of its greater potency and convenience in application, the same thing had to be said of radium as was said of the X-rays—that it could not in any sense be looked upon as a cure for cancerous growths of large size. It would inhibit the further growth of such tumours, and even destroy them locally, but rarely completely, and it did nothing to prevent the usual secondary deposits. In the diseases for which the rays possessed curative properties, their action was extraordinarily selective, so that, if the dosage were well timed, they would destroy the abnormal cells without destroying the normal.

The effect of the emanation of radium, which when dissolved could be injected into the tissues, or, like the salt, could be confined in a metal tube and buried, was practically the same as with radium itself. The emanation gave 75 per cent. of the energy which would be obtained if the radium from which it came were embedded in its stead. When introduced into the system by inhalation, by injection, or by swallowing, the emanation seemed to have a capacity for stimulating the body ferments. He produced a standard for the radium emanation which had been given to him by Sir William Ramsay. It was in the form of a bottle containing 1/40,000th part of a milligram of pure radium.

In conclusion, the lecturer turned to the possibility of other radio-active substances, less forbidding in price and more readily available, taking the place of radium. Uranium, thorium, and actinium were radio-active, and had all been suggested in this connection, but they were too feeble to have any real efficacy. The discovery by Otto Hahn of a substance known as meso-thorium, which was one of the disintegration products of thorium, and was found in the course of an attempt to separate radio-thorium directly from thorium, had aroused considerable expectation. Meso-thorium emitted the same rays as radium, and, weight for weight, was more powerful. As the supply of thorium was much larger than that of pitchblende, from which radium was obtained, they might hope to have a larger supply of meso-thorium. It would cost much less, but, on the other hand, it had a short life of only about seven years. It was being experimented with medically in Germany. The lecturer had applied a tube, which he showed, equivalent to 10 mg. of pure radium, to a chronic patch of X-ray dermatitis on his hand, and a reaction followed fifteen days after application. The result promised to be favourable.

Radio-thorium gave off thorium emanation richly. This was a heavy gas, lasting seventy-six seconds, giving off α rays in profusion—rays which, impinging upon a sulphide of zinc screen, caused it to glow or fluoresce, a remarkable "spinthariscope" effect being observed when the screen was viewed with a magnifying glass. Thorium emanation also resembled that of radium in giving rise to an "active deposit," this becoming concentrated on the negative pole in an electric field. A metallic surface could in this way be made intensely radio-active, giving forth the α, β, and γ rays. The "active deposit" from the thorium emanation lasted for several hours. The lecture concluded with a very pretty demonstration of the thorium emanation passing through long tubes.